The SuperB physics case

Marco Ciuchini

INFN Roma Tre

What I discuss:

- what is precision flavour physics?
- why is interesting?
- what can we learn?
- which physics is probed?

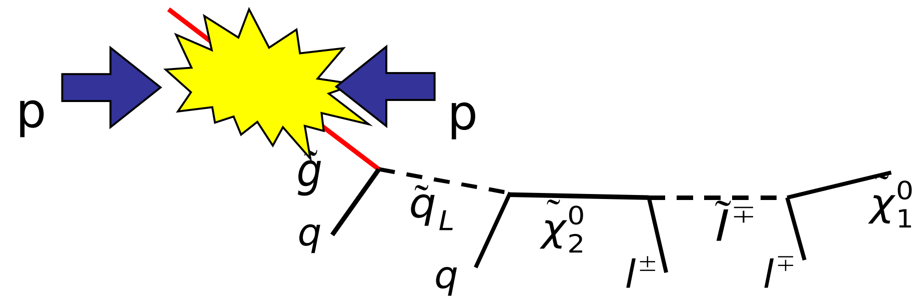
What I do not discuss:

- how to do precision flavour physics

--> next talk by M. Giorgi

The two paths to new physics

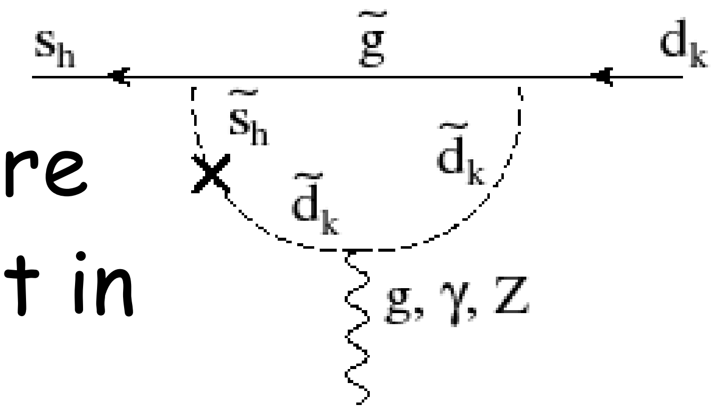
- **The "relativistic" path**



available CoM energy is used to produce *real* new heavy particles

Limiting factor: available CoM energy

- **The "quantum" path**



virtual new heavy particles are revealed through their effect in quantum corrections (loops)

Limiting factor: achievable precision

Why flavour physics?

In the SM flavour-changing neutral currents (FCNC) and CP-violating processes occur at the loop level and thus potentially receive O(1) NP corrections

SM quark FV and CPV are governed by the weak interactions and suppressed by the mixing angles, SM lepton FV is strongly suppressed by ($\delta m_\nu / M_W$)

NP not necessarily shares this pattern of suppressions and can give very large contributions

Flavour physics confronts NP searches

The problem of today particle physics:

where is the NP scale Λ? 0.5, 1, 10, 10^{13}, 10^{16} TeV??

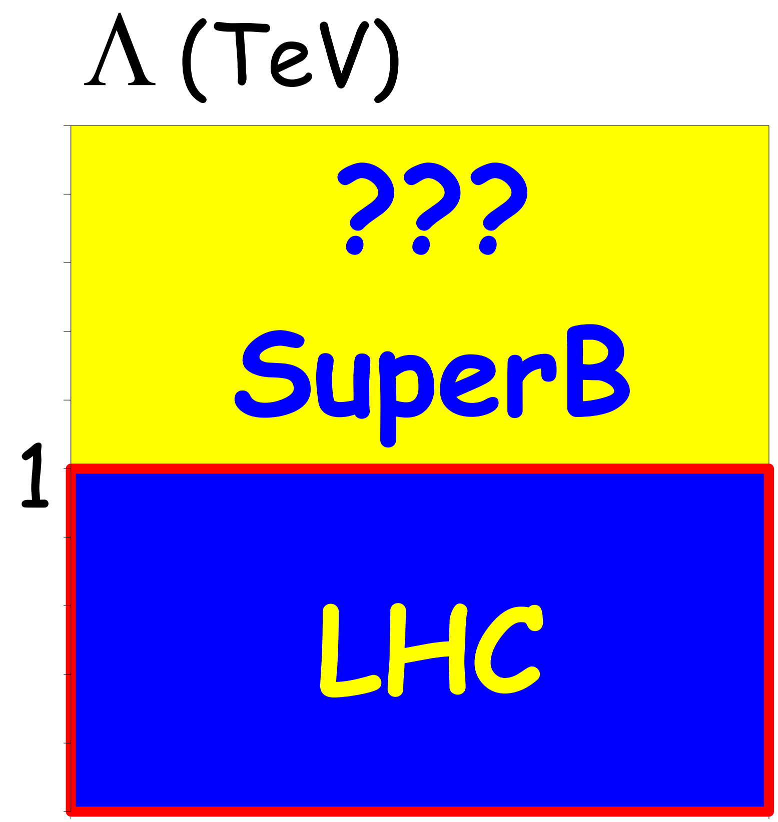
The quantum stabilization of the weak scale suggests $\leq$ 1 TeV

LHC searches in this range

What if the scale is just above, in the 10 TeV range?

Naturalness is not at loss yet

SuperB could be sensitive to physics in this range



New Flavour Physics: a problem of scale and couplings

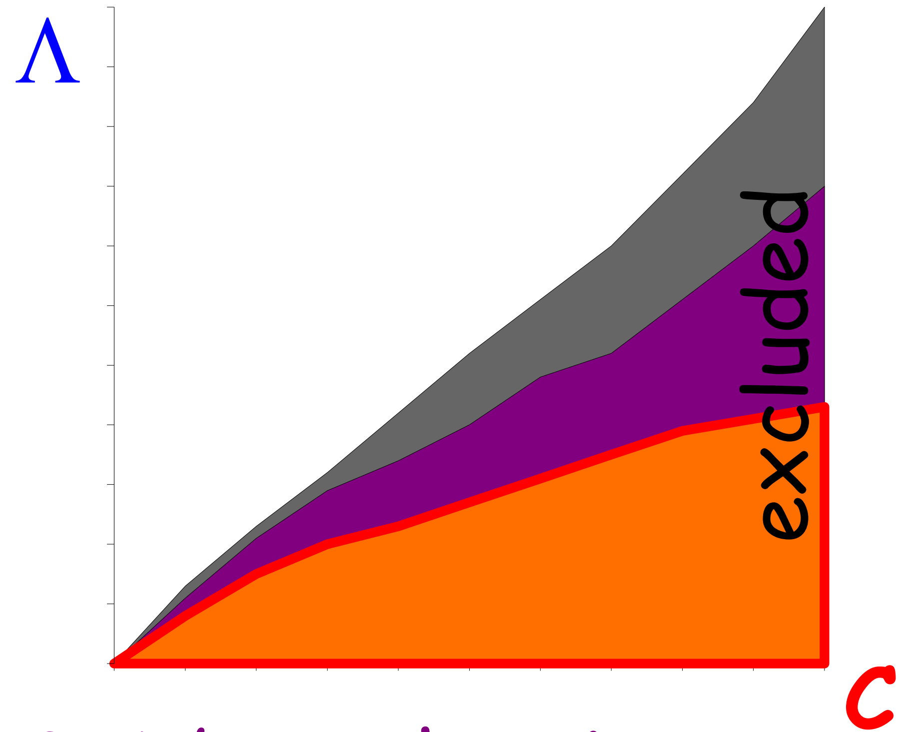
$$\mathcal{L} = \mathcal{L}_{SM} + \sum_{k=1} \left(\sum_i C_i^k \, Q_i^{(k+4)} \right) / \Lambda^k$$

NP effects are governed by:

- the value of the new physics scale Λ
- the effective flavour-violating couplings C's
  + couplings can follow a given pattern (e.g. dictated by symmetries)
  + couplings can have different strength (e.g. generated by different interactions)

Pictorially :

- exp. constraints give a bound on Λ for any given *C* and vice-versa
- curves correspond to different models



What do we do with this plot? *A* branch point

- **Λ is known (thanks LHC!)**

  determine the NP FV couplings C_i , study the flavour structure of NP, look for signal of heavier states

- **Λ is not known**

  look for indirect NP signals, understand where they may come from, exclude regions in parameter space

Crucial questions for NP searches with flavour

1. can NP be flavour blind? "no",
NP couples to SM which violates flavour

2. can a "worst case" be defined? "yes",
through the class of models with

Minimal Flavour Violation

NP follows the SM pattern of flavour and CP symmetry breaking

Gabrielli, Giudice, NPB433
Buras et al, NPB500
D'Ambrosio et al., NPB645

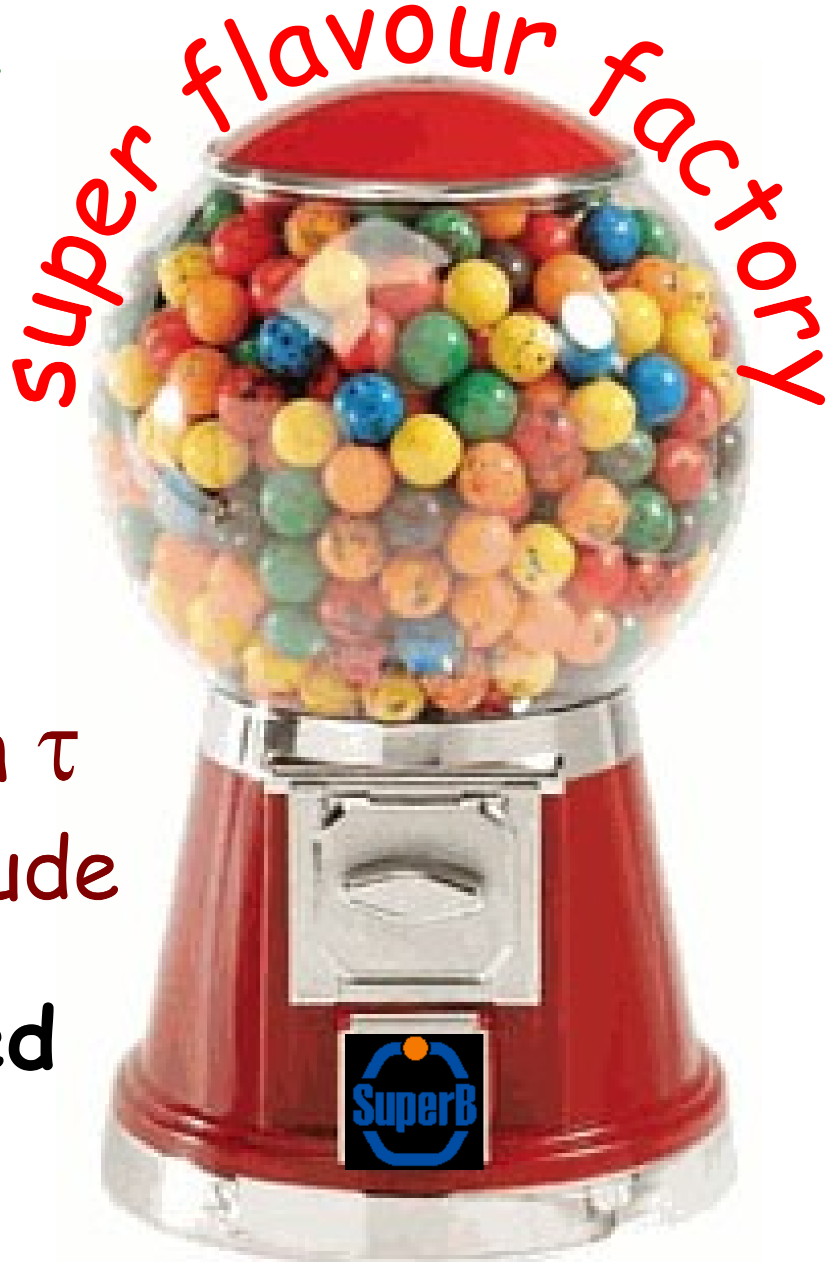
What does "precision" mean at SuperB?

- improve precision/sensitivity of previous measurements by a factor 5-10

- test the CKM paradigm at 1% level

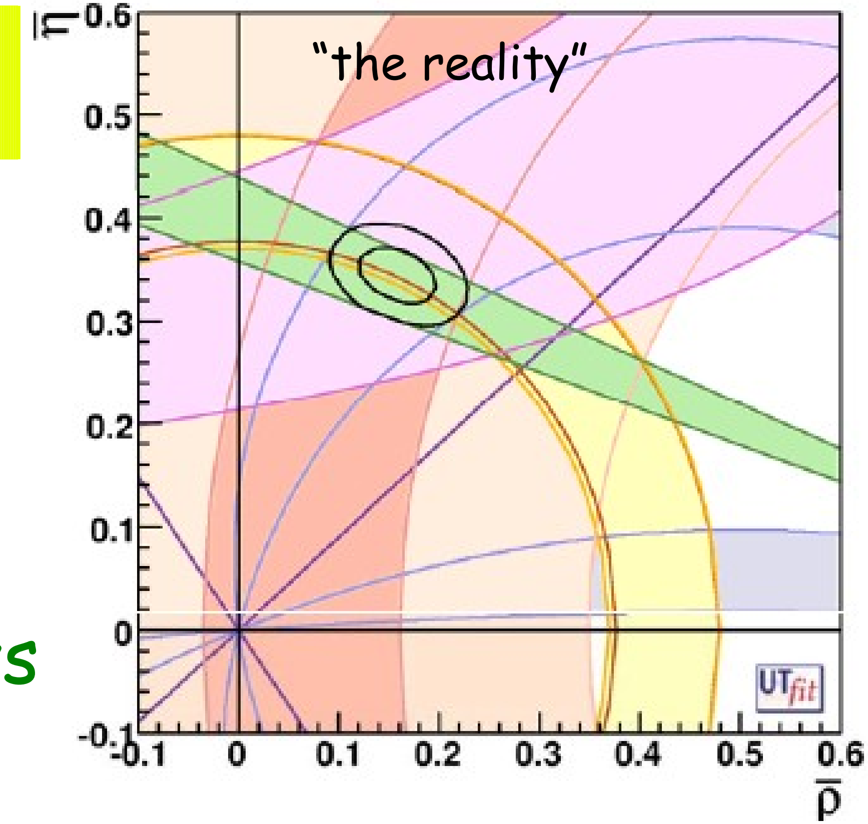
- increase sensitivity to LFV in τ decays by 1 order of magnitude

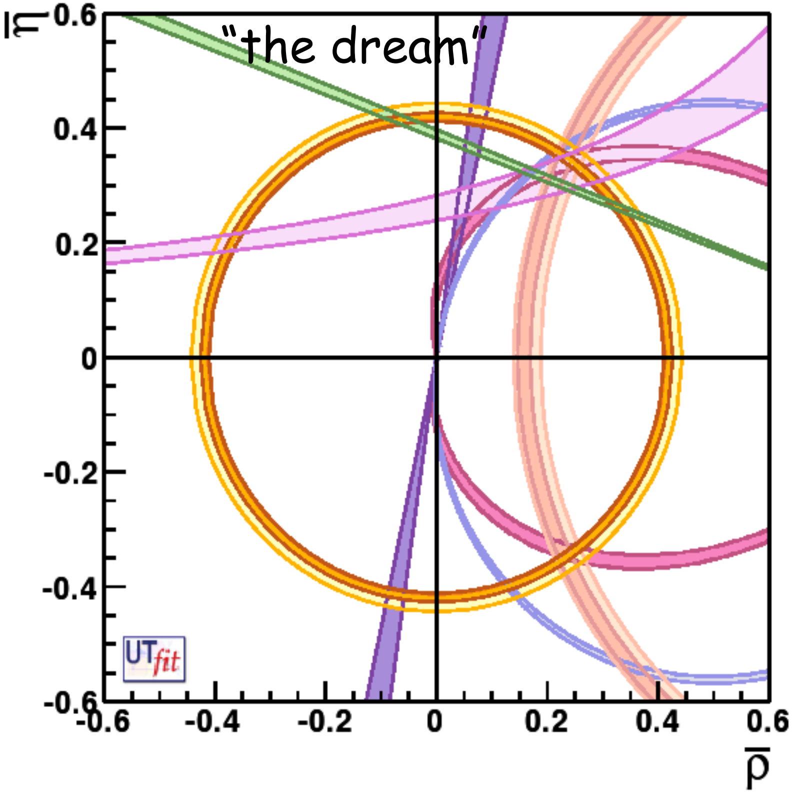
feasible with $75ab^{-1}$ collected at $\Upsilon(4S)$ i.e. with SuperB



dozens of observables

- A_{CP}(B->X γ)
- BR(τ->μ γ)
- A_{FB}(B->X ll)(m_{ll}^2)=0
- LU violation in B and τ decays
- CPV in τ and CF and DCS D decays





- CKM angles (many observables)
- BR(B->τ/μ ν), BR(B->D τ ν)
- $|V_{cb}|$, $|V_{ub}|$ from SL decays
- BR(B->ρ/ω γ), BR(B->K*γ)
- many others...

dozens of observables

- A_{CP}(B->X γ)
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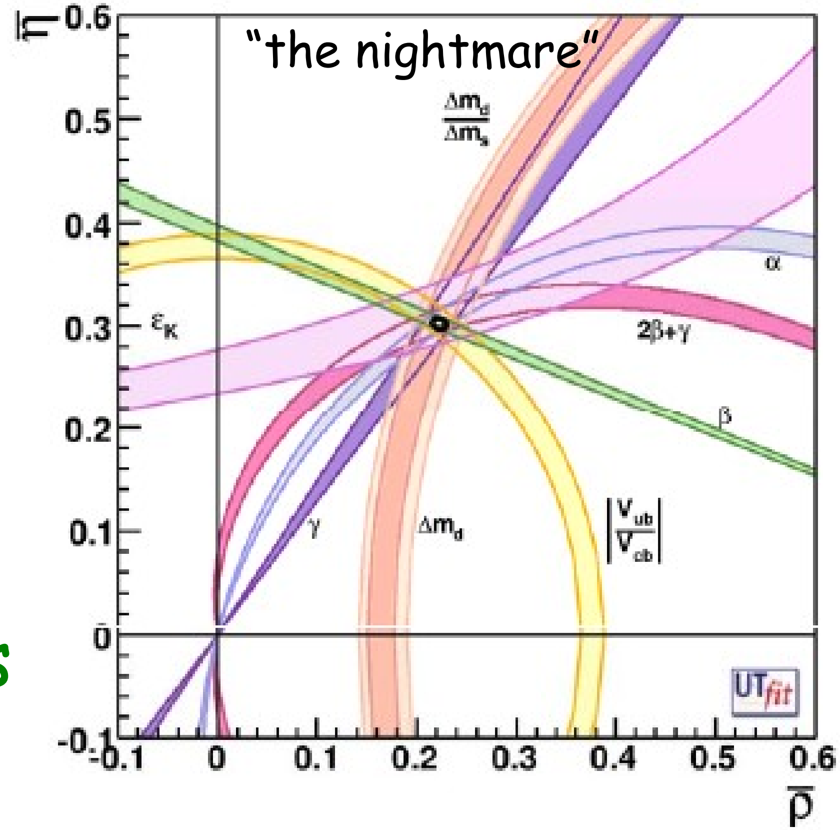

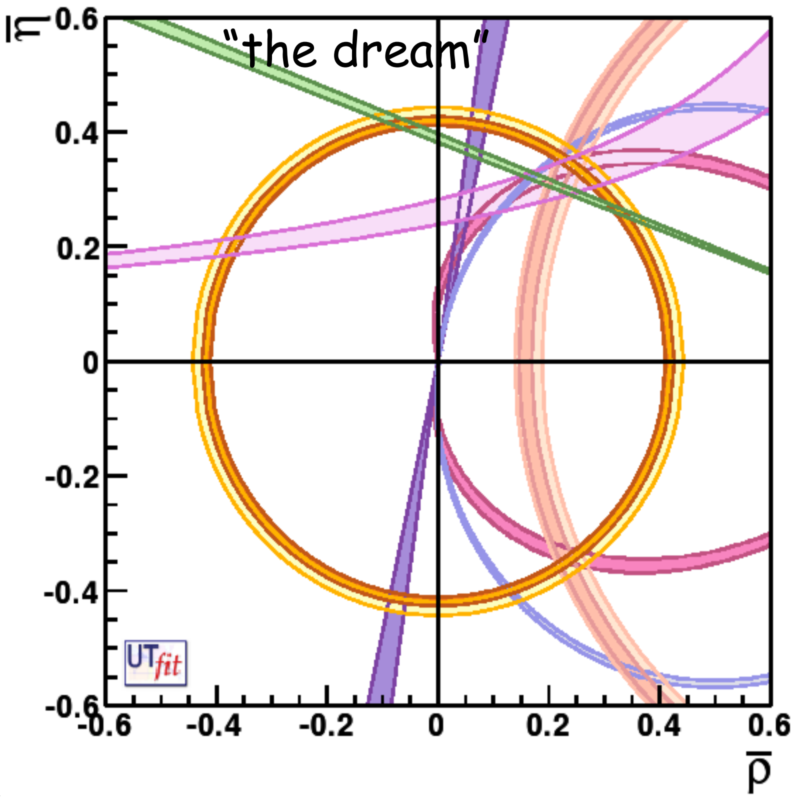

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- many others...

Are the measurements limited by systematics?

Observable	B factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$\sin(2\beta)$ $(J/\psi K^0)$	0.018	0.005 (†)
$\cos(2\beta)$ $(J/\psi K^{*0})$	0.30	0.05
$\sin(2\beta)$ (Dh^0)	0.10	0.02
$\cos(2\beta)$ (Dh^0)	0.20	0.04
$S(J/\psi\,\pi^0)$	0.10	0.02
$S(D^+D^-)$	0.20	0.03
$S(\phi K^0)$	0.13	0.02 (∗)
$S(\eta' K^0)$	0.05	0.01 (∗)
$S(K_S K_S K_S)$	0.15	0.02 (∗)
$S(K_S \pi^0)$	0.15	0.02 (∗)
$S(\omega K_S)$	0.17	0.03 (∗)
$S(f_0 K_S)$	0.12	0.02 (∗)
γ $(B \to DK,\ D \to CP$ eigenstates)	$\sim 15^o$	2.5^o
γ $(B \to DK,\ D \to$ suppressed states)	$\sim 12^o$	2.0^o
γ $(B \to DK,\ D \to$ multibody states)	$\sim 9^o$	1.5^o
γ $(B \to DK$, combined)	$\sim 6^o$	1–2^o
α $(B \to \pi\pi)$	$\sim 16^o$	3^o
α $(B \to \rho\rho)$	$\sim 7^o$	1–2^o (∗)
α $(B \to \rho\pi)$	$\sim 12^o$	2^o
α (combined)	$\sim 6^o$	1–2^o (∗)
$2\beta + \gamma$ $(D^{(*)\pm}\pi^\mp,\ D^\pm K_S \pi^\mp)$	20^o	5^o

Observable	B factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$\lvert V_{cb}\rvert$ (exclusive)	4% (∗)	1.0% (∗)
$\lvert V_{cb}\rvert$ (inclusive)	1% (∗)	0.5% (∗)
$\lvert V_{ub}\rvert$ (exclusive)	8% (∗)	2.0% (∗)
$\lvert V_{ub}\rvert$ (inclusive)	8% (∗)	2.0% (∗)
$\mathcal{B}(B \to \tau\nu)$	20%	4% (†)
$\mathcal{B}(B \to \mu\nu)$	visible	5%
$\mathcal{B}(B \to D\tau\nu)$	10%	2%
$\mathcal{B}(B \to \rho\gamma)$	15%	3% (†)
$\mathcal{B}(B \to \omega\gamma)$	30%	5%
$A_{CP}(B \to K^*\gamma)$	0.007 (†)	0.004 († ∗)
$A_{CP}(B \to \rho\gamma)$	~ 0.20	0.05
$A_{CP}(b \to s\gamma)$	0.012 (†)	0.004 (†)
$A_{CP}(b \to (s+d)\gamma)$	0.03	0.01 (†)
$S(K_S \pi^0 \gamma)$	0.15	0.02 (∗)
$S(\rho^0 \gamma)$	possible	0.10
$A_{CP}(B \to K^* ll)$	7%	1%
$A^{FB}(B \to K^* ll) s_0$	25%	9%
$A^{FB}(B \to X_s ll) s_0$	35%	5%
$\mathcal{B}(B \to K\nu\bar{\nu})$	visible	20%
$\mathcal{B}(B \to \pi\nu\bar{\nu})$	–	possible

Only few of them are even with 75 ab^{-1}

Theory keeps up...

- Lattice QCD can reach the O(1%) precision goal in time
- Some progress for inclusive techniques for SL B decays
- Non-leptonic B decays more problematic

Measurement	Hadronic Parameter	Present Error	6 TFlops	60 TFlops	1-10 PFlops (Year 2015)
$K \to \pi l \nu$	$f_+^{K\pi}(0)$	0.9 %	0.7 %	0.4 %	< 0.1 %
ε_K	$\hat{B}_K$	11 %	5 %	3 %	1 %
$B \to l \nu$	f_B	14 %	3.5-4.5 %	2.5-4.0 %	1.0-1.5 %
Δm_d	$f_{Bs}\sqrt{B_{B_s}}$	13 %	4-5 %	3-4 %	1-1.5 %
$\Delta m_d / \Delta m_s$	ξ	5 %	3 %	1.5-2 %	0.5-0.8 %
$B \to D/D^* l \nu$	$\mathcal{F}_{B \to D/D^*}$	4 %	2 %	1.2 %	0.5 %
$B \to \pi/\rho l \nu$	$f_+^{B\pi}, \ldots$	11 %	5.5-6.5 %	4-5 %	2-3 %
$B \to K^*/\rho\,(\gamma, l^+ l^-)$	$T_1^{B \to K^*/\rho}$	13 %	——	——	3-4 %

V. Lubicz, 4th SuperB Workshop and SuperB CDR

Minimal Flavour Violation

Gabrielli, Giudice, NPB433
Buras et al., NPB500
D'Ambrosio et al., NPB645

No new sources of flavour and CP violation beyond the SM

- NP contributions governed by SM Yukawa couplings
  ex.: Constrained MSSM (MSUGRA), Universal Extra Dim.
- NP only modifies SM top contribution to FCNC & CPV
  unless other Yukawa couplings are enhanced; for example large tanβ enhances bottom contributions

1HDM/2HDM at small tanβ	2HDM at large tanβ
same operators as in H_{eff}^{SM}	new operators wrt H_{eff}^{SM}
NP in K and B correlated	NP in K and B uncorrelated

Constraints on the MFV NP scale

D'Ambrosio et al., NPB645

MFV models with 1HD or 2HD @ low/moderate tanβ:
Universal NP effect in the ΔF=2 loop function of the top

$$\mathcal{H}_{\rm eff}^{\Delta F=2} = \mathcal{H}_{\rm SM} + \mathcal{H}_{\rm NP} = \left(V_{tq}V_{tq'}^*\right)^2 \left(\frac{S_0(x_t)}{\Lambda_0^2} + \frac{a_{\rm NP}}{\Lambda^2}\right) (\bar{q}'q)_{(V-A)}\,(\bar{q}'q)_{(V-A)}$$

$$S_0(x_t) \to S_0(x_t) + \delta S_0, \quad |\delta S_0| = O\left(4\frac{\Lambda_0^2}{\Lambda^2}\right), \quad \Lambda_0 = \frac{\pi Y_t}{\sqrt{2} G_F M_W} \sim 2.4\,\mathrm{TeV}$$

Today:

$\Lambda_{MFV} > 2.3\Lambda_0$ @95% prob.

NP masses > 200 GeV

SuperB:

$\Lambda_{MFV} > 6\Lambda_0$ @95% prob.

NP masses > 600 GeV

NB: constraints from ΔF=1 processes not included

The ΔB=2 effective Hamiltonian beyond MFV

$$H_{eff}^{\Delta=2} = \sum_{i=1}^{5} C_i(\mu) Q_i(\mu) + \sum_{i=1}^{3} \tilde{C}_i(\mu) \tilde{Q}_i(\mu)$$

$$Q_1 = \bar{q}_L^\alpha \gamma_\mu b_L^\alpha \, \bar{q}_L^\beta \gamma^\mu b_L^\beta \qquad \text{(SM/MFV)}$$

$$Q_2 = \bar{q}_R^\alpha b_L^\alpha \, \bar{q}_R^\beta b_L^\beta \qquad Q_3 = \bar{q}_R^\alpha b_L^\beta \, \bar{q}_R^\beta b_L^\beta$$

$$Q_4 = \bar{q}_R^\alpha b_L^\alpha \, \bar{q}_L^\beta b_R^\beta \qquad Q_5 = \bar{q}_R^\alpha b_L^\beta \, \bar{q}_L^\beta b_R^\beta$$

$$\tilde{Q}_1 = \bar{q}_R^\alpha \gamma_\mu b_R^\alpha \, \bar{q}_R^\beta \gamma^\mu b_R^\beta$$

$$\tilde{Q}_2 = \bar{q}_L^\alpha b_R^\alpha \, \bar{q}_L^\beta b_R^\beta \qquad \tilde{Q}_3 = \bar{q}_L^\alpha b_R^\beta \, \bar{q}_L^\beta b_R^\beta$$

7 new operators involving quarks with different chiralities

H_{eff} can be recast in terms of the high-scale $C_i(\Lambda)$

- $C_i(\Lambda)$ can be extracted from the data (one by one)
- the associated NP scale Λ can be defined as

$$\Lambda = \sqrt{\frac{L F_i}{C_i(\Lambda)}}$$

strongly interacting NP: $L \sim 1$

weakly interacting NP: $L \sim \alpha_{W,s}^2$

MFV: $F_1 = F_{SM} \sim (V_{tq} V_{tb}^*)^2$, $F_{i \neq 1} = 0$ and $L \sim \alpha_W^2$

generic flavour structure	next-to-MFV
- $\lvert F_i \rvert \sim 1$	- $\lvert F_i \rvert \sim F_{SM}$
- arbitrary phases	- arbitrary phases

UTfit collaboration, in preparation

PRELIMINARY

generic FV

B_d Sector

$Re(C_d^1)$	$[-0.9, 3.9]10^{-12}$	$Im(C_d^1)$	$[-1.0, 3.7]10^{-12}$
$Re(C_d^2)$	$[-1.5, 0.4]10^{-12}$	$Im(C_d^2)$	$[-1.5, 0.4]10^{-12}$
$Re(C_d^3)$	$[-1.2, 5.7]10^{-12}$	$Im(C_d^3)$	$[-1.5, 5.3]10^{-12}$
$Re(C_d^4)$	$[-0.8, 4.8]10^{-13}$	$Im(C_d^4)$	$[-1.2, 0.4]10^{-12}$
$Re(C_d^5)$	$[-0.3, 1.2]10^{-12}$	$Im(C_d^5)$	$[-0.3, 1.2]10^{-12}$

Λ>1800 TeV@95% prob.

NMFV

B_d Sector

$Re(C_d^1)$	$[-0.7, 2.8]10^{-8}$	$Im(C_d^1)$	$[-0.7, 2.6]10^{-8}$
$Re(C_d^2)$	$[-14.4, 3.6]10^{-9}$	$Im(C_d^2)$	$[-14.3, 3.9]10^{-9}$
$Re(C_d^3)$	$[-1.1, 5.6]10^{-8}$	$Im(C_d^3)$	$[-1.5, 5.2]10^{-8}$
$Re(C_d^4)$	$[-1.1, 4.8]10^{-9}$	$Im(C_d^4)$	$[-1.3, 4.7]10^{-9}$
$Re(C_d^5)$	$[-0.3, 1.3]10^{-8}$	$Im(C_d^5)$	$[-0.7, 1.2]10^{-8}$

Λ_{NMFV}>14 TeV@95% prob.

- ΔB=2 chirality-flipping operators are RG enhanced and thus probe larger NP scales
- when scalar operators are allowed, the NP scale is easily pushed beyond the LHC reach

SuperB: typically 3 x present bounds

Higgs-mediated NP in MFV at very large tanβ

$$\mathrm{BR}(B\to\tau\nu)=\mathrm{BR}_{SM}(B\to\tau\nu)\left(1-\frac{m_B^2}{M_H^2}\tan^2\beta\right)^2$$

$H^{\pm}$-exchange in 2HDM-II easily accounted for

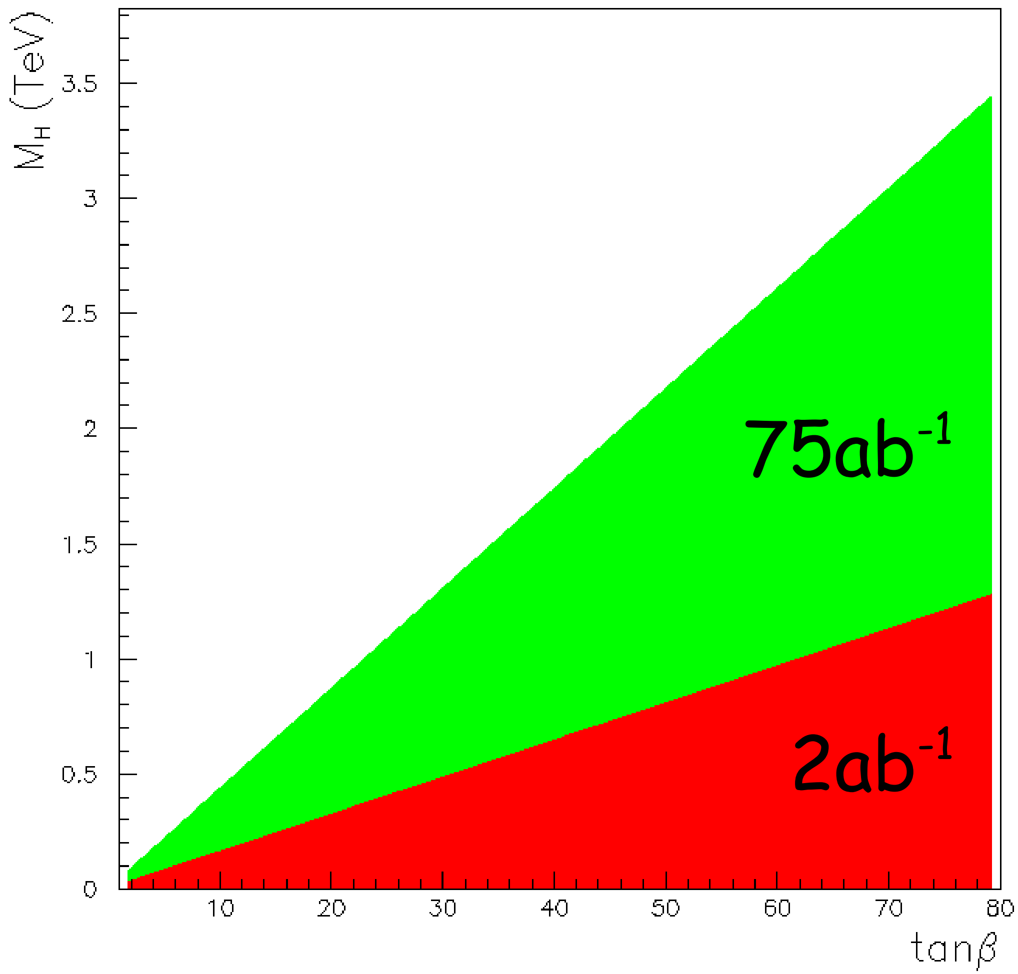
Similar formula in MSSM

BaBar+Belle:

sensitive to M_H~0.4-0.8 TeV for tanβ~30-60

SFF:

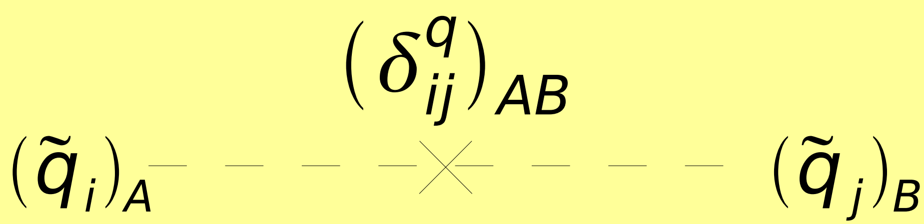
sensitive to M_H~1.2-2.5 TeV for tanβ~30-60



A popular non-MFV model: MSSM + generic soft SUSY-breaking terms

few NP models are MFV, much larger effects are common: for example MSSM+MIs

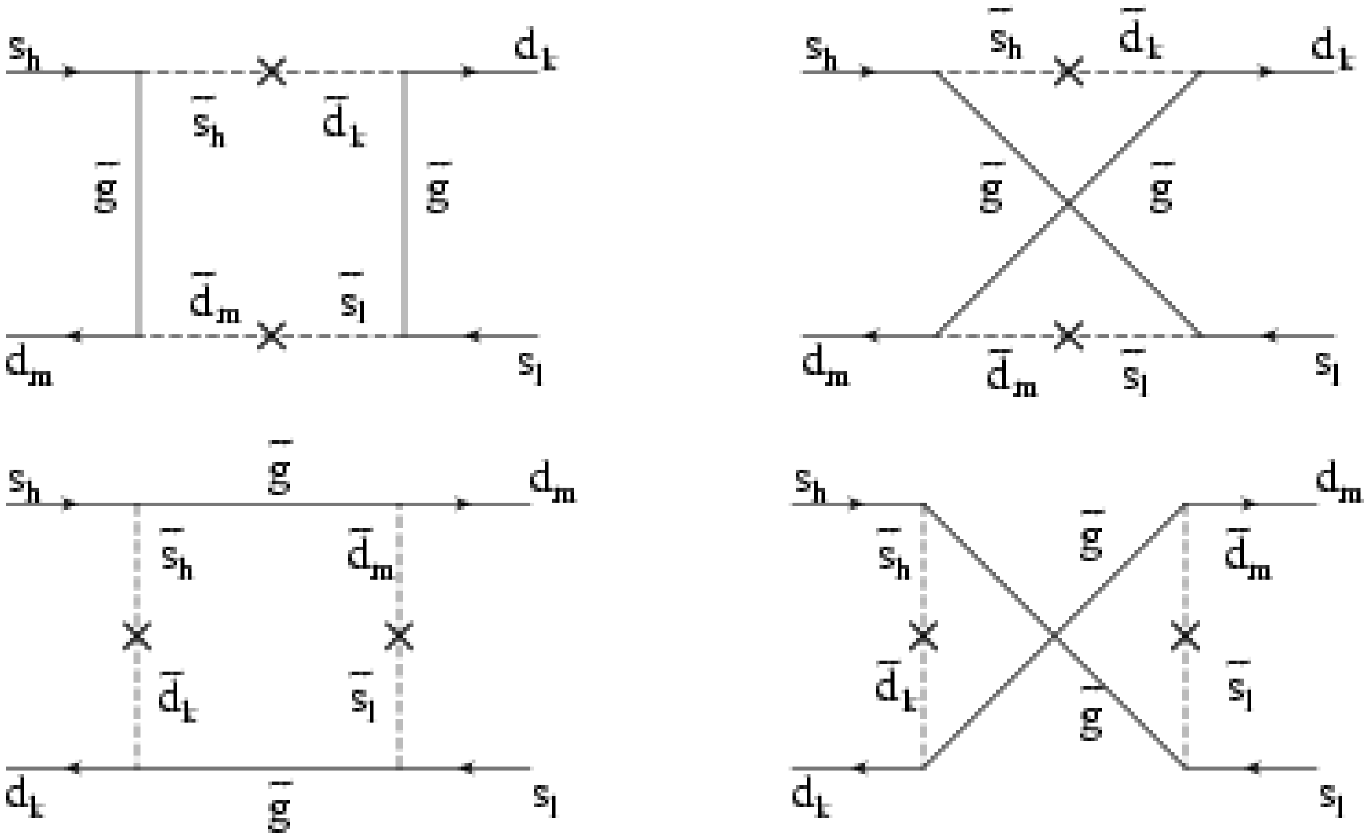
All flavour-changing NP effects in the squark propagators



$q=\{u,d\}$, $(A,B)=\{L,R\}$
$(i,j)=\{1,2,3\}$

- NP scale: SUSY masses $\tilde{m} \sim m_{\tilde{g}}$
- flavour-violating couplings: $(\delta^q_{ij})_{AB} \equiv \frac{(M^2_{ij})^q_{AB}}{\tilde{m}^2}$

NB: only dominant gluino contributions are considered



gluino-squark contributions to the Wilson coefficients

Gabbiani et al., hep-ph/9604387

$$C_1=\frac{\alpha_s^2}{\tilde{m}^2}(\delta_{12}^d)_{LL}^2 f_1(x) \quad C_2=\frac{\alpha_s^2}{\tilde{m}^2}(\delta_{12}^d)_{RL}^2 f_2(x) \quad C_3=\frac{\alpha_s^2}{\tilde{m}^2}(\delta_{12}^d)_{RL}^2 f_3(x)$$

$$\tilde{C}_1=\frac{\alpha_s^2}{\tilde{m}^2}(\delta_{12}^d)_{RR}^2 f_1(x) \quad \tilde{C}_2=\frac{\alpha_s^2}{\tilde{m}^2}(\delta_{12}^d)_{LR}^2 f_2(x) \quad \tilde{C}_3=\frac{\alpha_s^2}{\tilde{m}^2}(\delta_{12}^d)_{LR}^2 f_3(x)$$

$$C_4=\frac{\alpha_s^2}{\tilde{m}^2}\left[(\delta_{12}^d)_{LL}(\delta_{12}^d)_{RR} f_4(x)+(\delta_{12}^d)_{LR}(\delta_{12}^d)_{RL}\tilde{f}_4(x)\right]$$

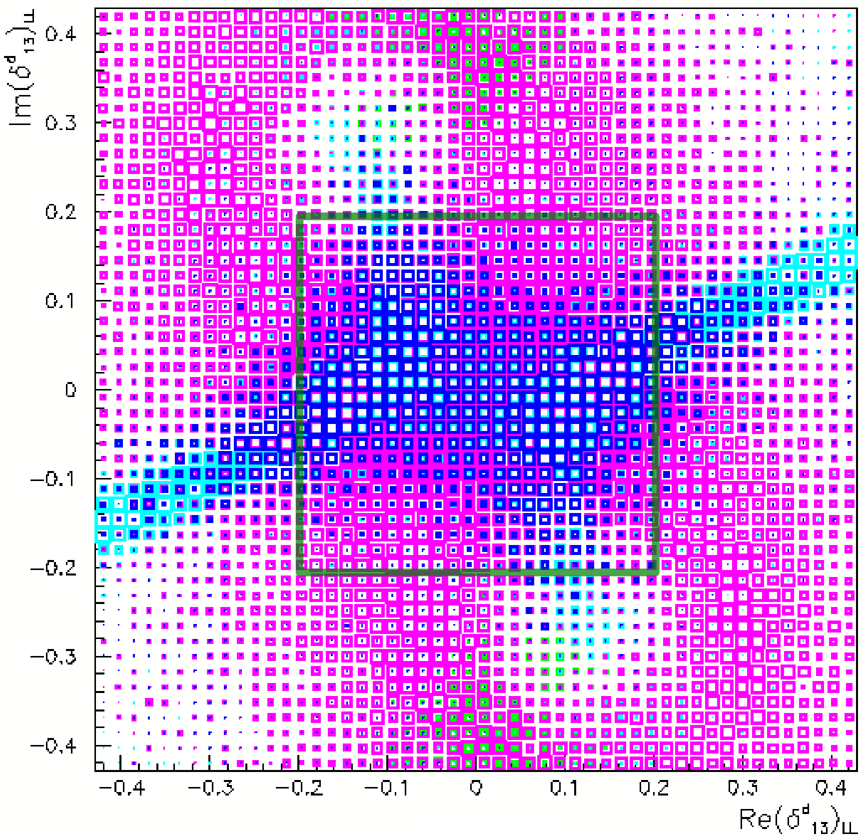
$$C_5=\frac{\alpha_s^2}{\tilde{m}^2}\left[(\delta_{12}^d)_{LL}(\delta_{12}^d)_{RR} f_5(x)+(\delta_{12}^d)_{LR}(\delta_{12}^d)_{RL}\tilde{f}_5(x)\right]$$

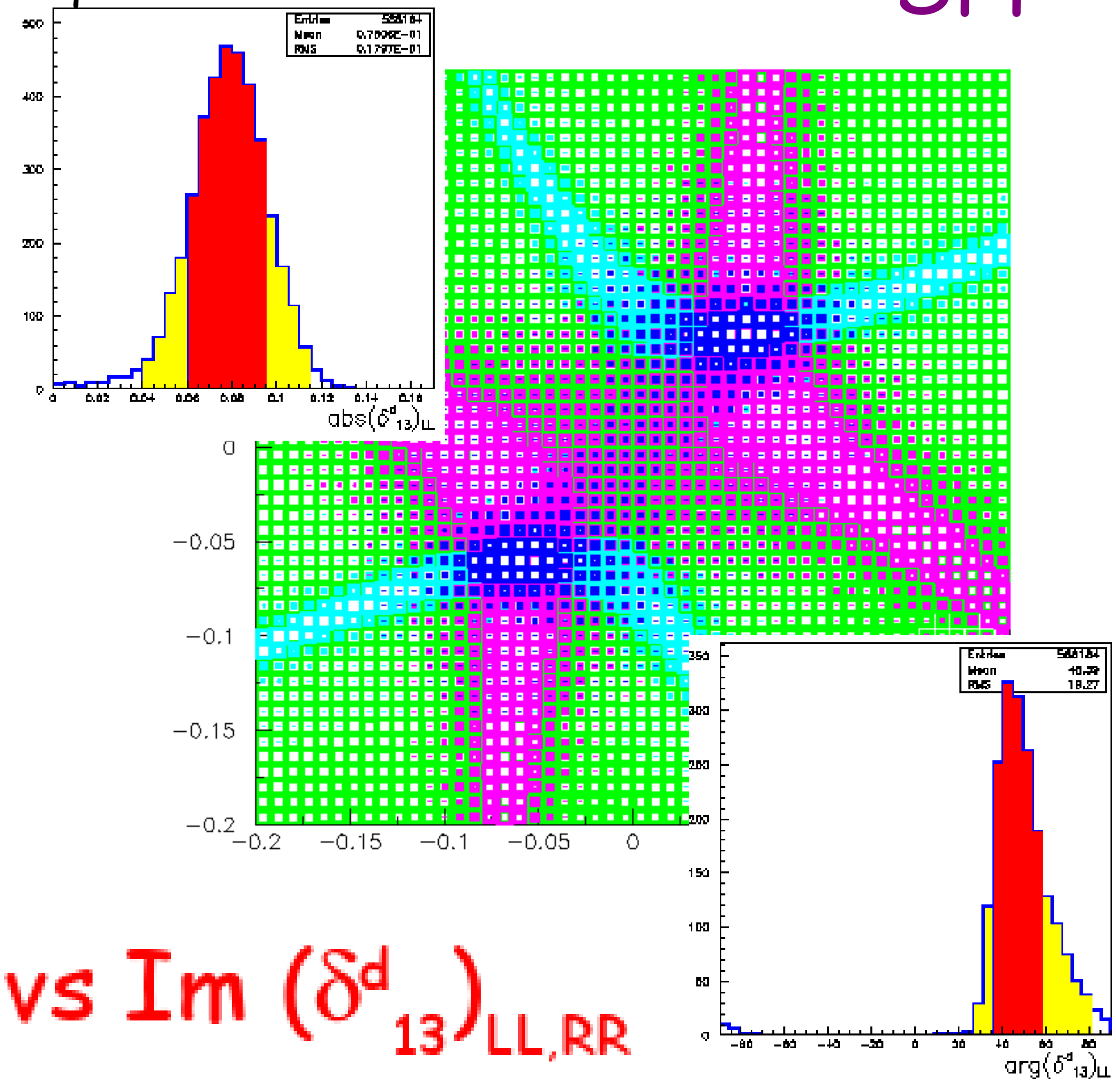
trivial changes in the case $\Delta B=2$

today

$\Lambda = m_{\tilde{g}} = m_{\tilde{q}} = 1$ TeV

SFF





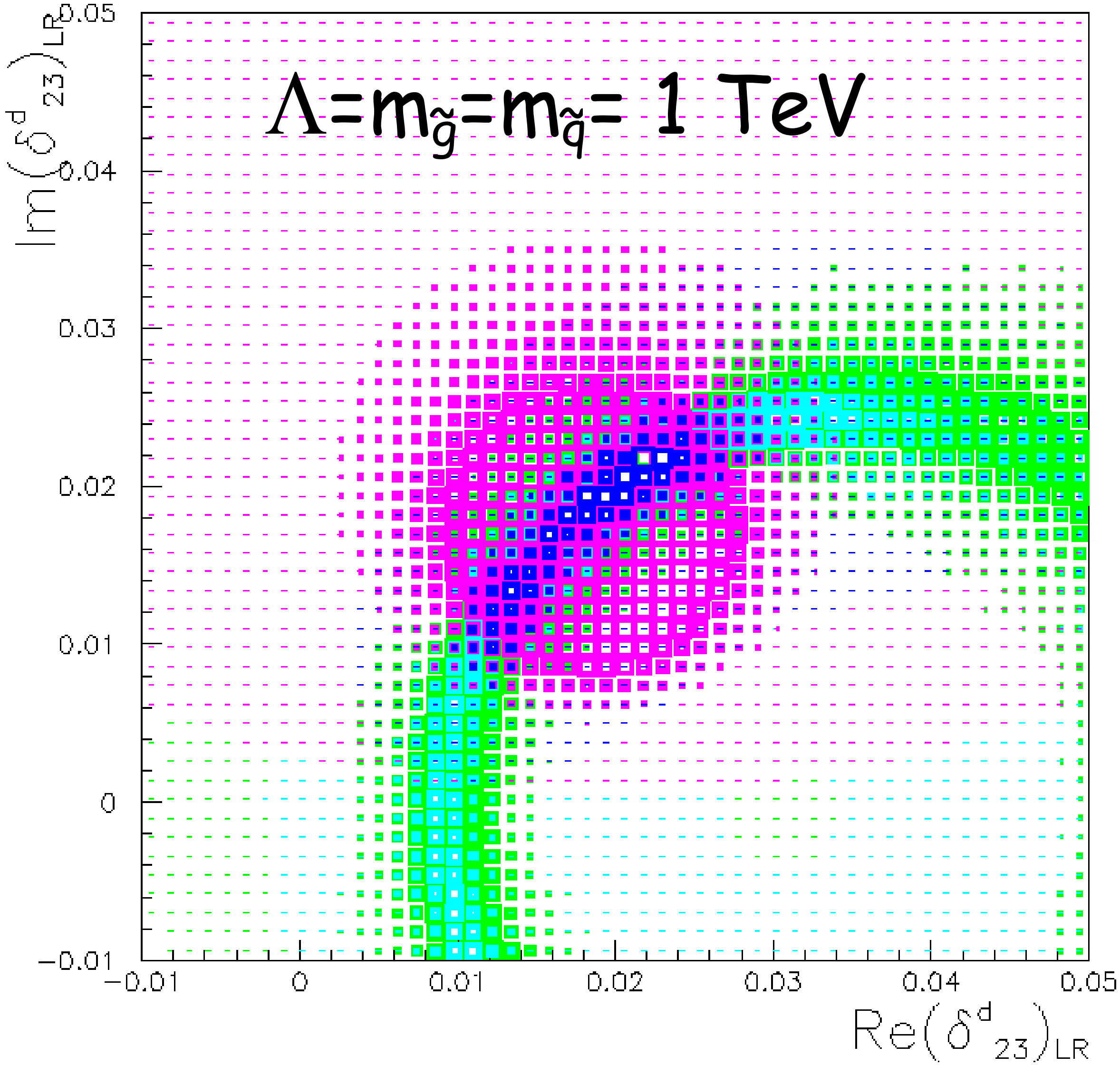
Re $(\delta^d_{13})_{LL,RR}$ vs Im $(\delta^d_{13})_{LL,RR}$

Δm_B only

A^d_{SL} only

sin 2β and cos 2β

All constraints



$A_{CP}(B\text{->}X\ \gamma)$ only

$BR(B\text{->}X\ \gamma)$ only

$BR(B\text{->}X\ l^+l^-)$ only

All constraints

Re $(\delta^d{}_{23})_{LR}$ vs Im $(\delta^d{}_{23})_{LR}$

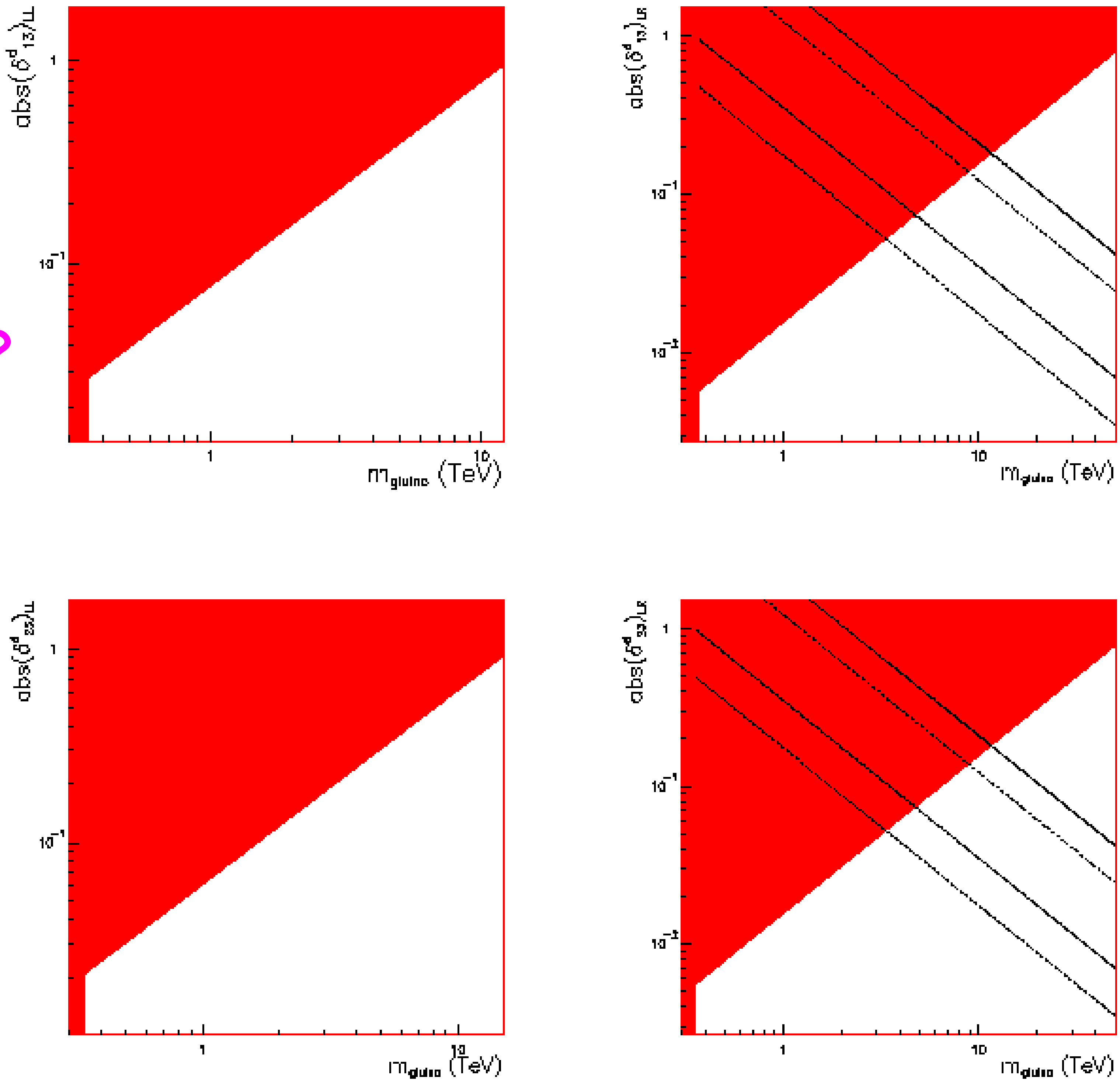
For fixed Λ (e.g. $m_{\tilde{g}}=m_{\tilde{q}}=1$ TeV): bounds on the FV couplings, i.e. the mass insertions $(\delta^q_{ij})_{AB}$

for ex. $(\delta^d_{13})_{LL,RR} < 2\times10^{-1}$ and $(\delta^d_{13})_{LR,RL} < 3\times10^{-2}$

As the bound approximately scales linearly with δ/Λ, for natural values $(\delta^d_{13})_{AB}$ in general MSSM at present one probes NP scales up to ~5 TeV

	general MSSM	high-scale MFV
$\left\|\left(\delta^d_{13}\right)_{LL}\right\|$ $(LL \gg RR)$	1	$\sim 10^{-3}\frac{(350\mathrm{GeV})^2}{m_{\tilde{q}}^2}$
$\left\|\left(\delta^d_{13}\right)_{LL}\right\|$ $(LL \sim RR)$	1	–
$\left\|\left(\delta^d_{13}\right)_{LR}\right\|$	$\sim 10^{-1}\tan\beta\frac{(350\mathrm{GeV})}{m_{\tilde{q}}}$	$\sim 10^{-4}\tan\beta\frac{(350\mathrm{GeV})^3}{m_{\tilde{q}}^3}$
$\left\|\left(\delta^d_{23}\right)_{LR}\right\|$	$\sim 10^{-1}\tan\beta\frac{(350\mathrm{GeV})}{m_{\tilde{q}}}$	$\sim 10^{-3}\tan\beta\frac{(350\mathrm{GeV})^3}{m_{\tilde{q}}^3}$

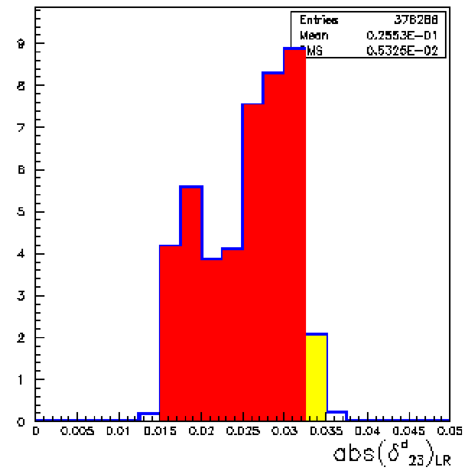
Which is the minimum coupling for which SuperB gives evidence of a non-vanishing δ?



In the red regions the δ's reconstructed using SFF constraints are more than 3σ away from 0

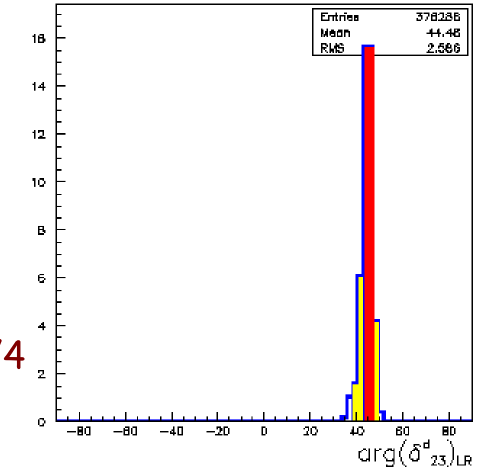
FV effects can originate from >TeV scales, but lower scales are not excluded. If NP is indeed in the TeV range: flavour-LHC complementarity

- LHC finds SUSY particle(s) and set the NP scale
- flavour physics determines the flavour-violating couplings and the SUSY breaking pattern



$m_{\tilde{q}} = m_{\tilde{g}} = 1\,\mathrm{TeV}$

simulated reconstruction of $(\delta^d_{23})_{LR}$



Unique opportunity to "measure" the SUSY model and eventually reconstruct the NP Lagrangian

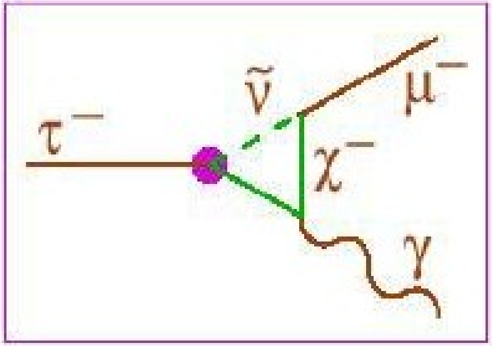
$(\delta^d_{23})_{LR} = 0.028e^{i\pi/4}$

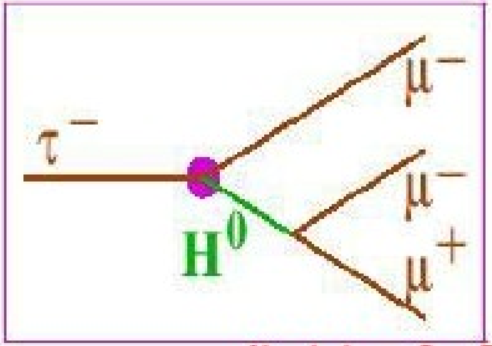
Lepton Flavour Violation: $\tau \to \mu \gamma$

Negligibly small in the SM

	$\mathcal{B}(\tau \to \ell\gamma)$	$\mathcal{B}(\tau \to \ell\ell\ell)$
mSUGRA+seesaw (EPJC14(2000)319, PRD66(2002)115013)	10^{-7}	10^{-9}
SUSY SO(10) (NPB649(2003)189, PRD68(2003)033012)	10^{-8}	10^{-10}
SUSY Higgs (PLB549(2002)159, PLB566(2003)217)	10^{-10}	10^{-7}
Non-Universal Z' (PLB547(2002)252)	10^{-9}	10^{-8}
SM+Heavy Majorana ν_R (PRD66(2002)034008)	10^{-9}	10^{-10}

different correlations with $\tau \to l\mu\mu$ and $\tau \to l\eta$ if Higgs or chargino exchange dominates





Roney's talk at the 4th SuperB workshop

compiled by S. Banerjee for Nov04 LHC Flavour Workshop

BR sensitivity

B-factories: ~ 10^{-8}

SuperB: ~ 10^{-9}

not just yet-another order of magnitude

sensitivity at SuperB

Process	Sensitivity
$\mathcal{B}(\tau \to \mu\,\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to e\,\gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to \mu\,\mu\,\mu)$	2×10^{-10}
$\mathcal{B}(\tau \to eee)$	2×10^{-10}
$\mathcal{B}(\tau \to \mu\eta)$	4×10^{-10}
$\mathcal{B}(\tau \to e\eta)$	6×10^{-10}
$\mathcal{B}(\tau \to \ell K^0_s)$	2×10^{-10}

Upper limits on LFV τ BRs in the littlest Higgs model with T-parity for f=500 GeV

$\tau \to e\gamma$	$1 \cdot 10^{-8}$
$\tau \to \mu\gamma$	$2 \cdot 10^{-8}$
$\tau^- \to e^-e^+e^-$	$2 \cdot 10^{-8}$
$\tau^- \to \mu^-\mu^+\mu^-$	$3 \cdot 10^{-8}$
$\tau^- \to e^-\mu^+\mu^-$	$2 \cdot 10^{-8}$
$\tau^- \to \mu^-e^+e^-$	$2 \cdot 10^{-8}$
$\tau^- \to \mu^-e^+\mu^-$	$2 \cdot 10^{-14}$
$\tau^- \to e^-\mu^+e^-$	$2 \cdot 10^{-14}$

Blanke et al., hep-ph/0702136

BR ratios can distinguish LHT from SUSY

ratio	LHT	MSSM (dipole)	MSSM (Higgs)
$\frac{\mathcal{B}(\tau^-\to e^-e^+e^-)}{\mathcal{B}(\tau\to e\gamma)}$	0.4...2.3	$\sim 1\cdot 10^{-2}$	$\sim 1\cdot 10^{-2}$
$\frac{\mathcal{B}(\tau^-\to \mu^-\mu^+\mu^-)}{\mathcal{B}(\tau\to \mu\gamma)}$	0.4...2.3	$\sim 2\cdot 10^{-3}$	0.06...0.1
$\frac{\mathcal{B}(\tau^-\to e^-\mu^+\mu^-)}{\mathcal{B}(\tau\to e\gamma)}$	0.3...1.6	$\sim 2\cdot 10^{-3}$	0.02...0.04
$\frac{\mathcal{B}(\tau^-\to \mu^-e^+e^-)}{\mathcal{B}(\tau\to \mu\gamma)}$	0.3...1.6	$\sim 1\cdot 10^{-2}$	$\sim 1\cdot 10^{-2}$
$\frac{\mathcal{B}(\tau^-\to e^-e^+e^-)}{\mathcal{B}(\tau^-\to e^-\mu^+\mu^-)}$	1.3...1.7	~ 5	0.3...0.5
$\frac{\mathcal{B}(\tau^-\to \mu^-\mu^+\mu^-)}{\mathcal{B}(\tau^-\to \mu^-e^+e^-)}$	1.2...1.6	~ 0.2	5...10

An example: lepton MFV and GUT

Isidori's talk at the 4th SuperB workshop

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

PMNS mixing strucutre [MLFV],

dominant if $M_R > 10^{12}$ GeV $\Rightarrow$ $B(\mu \to e\gamma) \sim 10^{-13}\,(M_R/10^{12}\text{GeV})\,(\Lambda/10\,\text{GeV})^4$

CKM mixing structure [~ Barbieri-Hall-Strumia '95]

dominant if $M_R < 10^{12}$ GeV $\Rightarrow$ $B(\mu \to e\gamma) \sim 10^{-13}\,(\Lambda/10\,\text{GeV})^4$

The search for $\tau \to \mu(e)\,\gamma$ at B and super-B factories becomes very interesting $\Rightarrow$ best tool to discriminate the two scenarios :

$$B(\tau \to \mu\gamma):B(\tau \to e\gamma):B(\mu \to e\gamma) \sim \lambda^{-6}:\lambda^{-4}:1 \sim 10^4:500:1$$

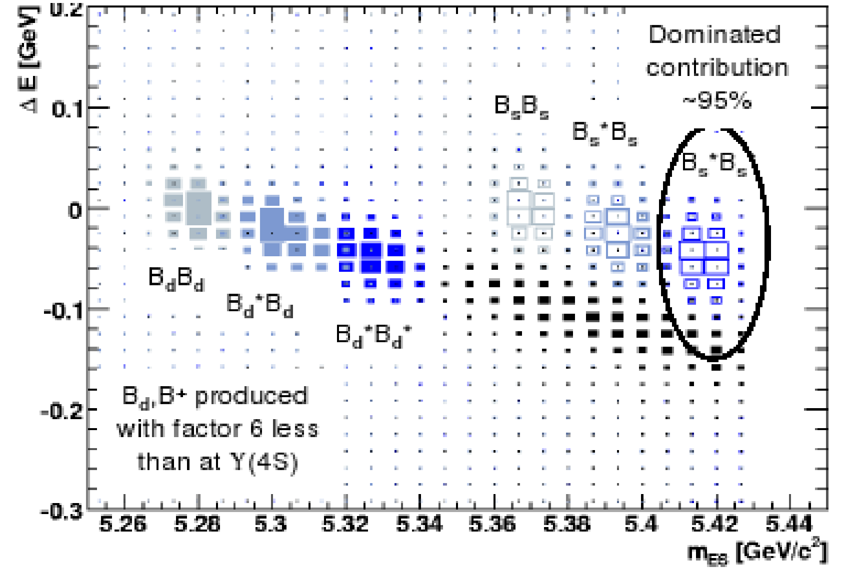
$$B(\tau \to \mu\gamma):B(\tau \to e\gamma):B(\mu \to e\gamma) \sim [500\text{–}10]:1:1$$

Run at the Υ(5S) → Possible with the same luminosity

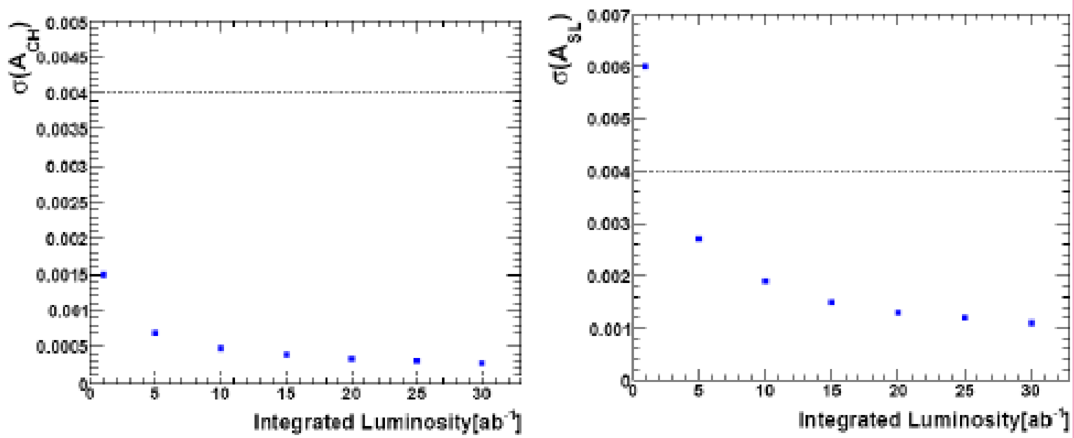
Observable	Error with 1 ab^{-1}	Error with 30 ab^{-1}
$\Delta\Gamma$	0.16 ps^{-1}	0.03 ps^{-1}
Γ	0.07 ps^{-1}	0.01 ps^{-1}
β_s from angular analysis	20°	8°
A^s_{SL}	0.006	0.004
A_{CH}	0.004	0.004
$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	$< 8 \times 10^{-9}$
$\lvert V_{td}/V_{ts} \rvert^*$	0.08	0.017
$\mathcal{B}(B_s \to \gamma\gamma)$	38%	7%
β_s from $J/\psi\phi$	16°	6°
β_s from $B_s \to K^0 \bar{K}^0$	24°	11°

*: $\mathcal{B}(B^0_s \to K^{*0}\gamma)/\mathcal{B}(B^0_d \to K^{*0}\gamma)$.

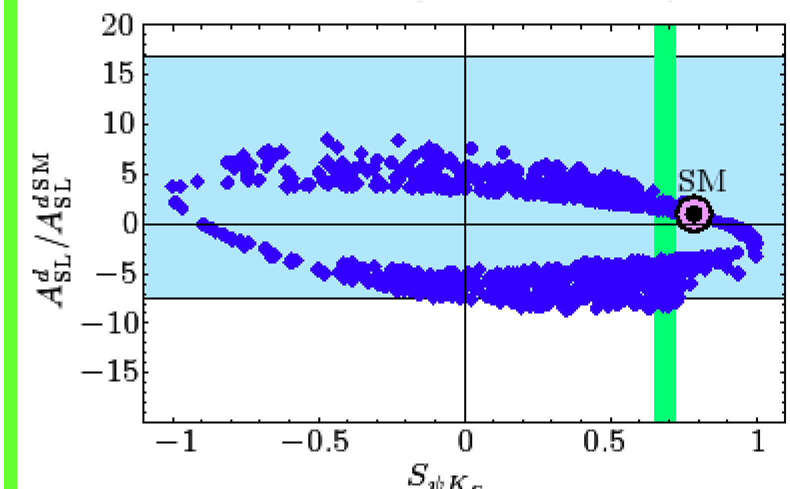
$B_d(B^+)$ and B_s are produced and can be separated



Integrated quantities A_{SL} and A_{CH} at less than 0.5%
Even a run at 1ab^{-1} will give less 1% error.



Detectable effects in A_{SL}^s in LHT models



For more details see E. Baracchini et al. hep-ph/0703258

Charm Physics

Charm physics using the charm produced at $\Upsilon(4S)$

Charm physics at threshold **0.2 ab^{-1}**

Consider that running 1 month at threshold we will collect 500 times the stat. of CLEO-C

String dynamics and CKM measurements

@threshold(4GeV)

D decay form factor and decay constant @ 1%
Dalitz structure useful for γ measurement

ξ~1%,
exclusive V_{ub} ~ few %
syst. error on γ from Dalitz Model <1°

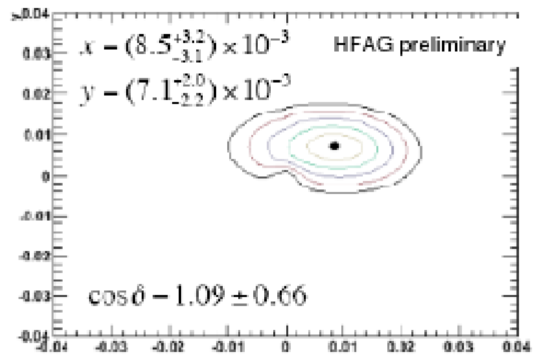
Rare decays FCNC down to 10^{-8}

@threshold(4GeV)

Channel	Sensitivity
$D^0 \to e^+e^-$, $D^0 \to \mu^+\mu^-$	1×10^{-8}
$D^0 \to \pi^0 e^+e^-$, $D^0 \to \pi^0\mu^+\mu^-$	2×10^{-8}
$D^0 \to \eta e^+e^-$, $D^0 \to \eta\mu^+\mu^-$	3×10^{-8}
$D^0 \to K^0_s e^+e^-$, $D^0 \to K^0_s\mu^+\mu^-$	3×10^{-8}
$D^+ \to \pi^+ e^+e^-$, $D^+ \to \pi^+\mu^+\mu^-$	1×10^{-8}
$D^0 \to e^\pm\mu^\mp$	1×10^{-8}
$D^+ \to \pi^+ e^\pm\mu^\mp$	1×10^{-8}
$D^0 \to \pi^0 e^\pm\mu^\mp$	2×10^{-8}
$D^0 \to \eta e^\pm\mu^\mp$	3×10^{-8}
$D^0 \to K^0_s e^\pm\mu^\mp$	3×10^{-8}
$D^+ \to \pi^- e^+e^+$, $D^+ \to K^- e^+e^+$	1×10^{-8}
$D^+ \to \pi^-\mu^+\mu^+$, $D^+ \to K^-\mu^+\mu^+$	1×10^{-8}
$D^+ \to \pi^- e^\pm\mu^\mp$, $D^+ \to K^- e^\pm\mu^\mp$	1×10^{-8}

D mixing

Better studied using the high statistics collected at $\Upsilon(4S)$



Mode	Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$D^0 \to K^+K^-$	y_{CP}	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
$D^0 \to K^+\pi^-$	y'_D	$2\text{–}3 \times 10^{-3}$	7×10^{-4}
	x'^2_D	$1\text{–}2 \times 10^{-4}$	3×10^{-5}
$D^0 \to K^0_s\pi^+\pi^-$	y_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}
Average	y_D	$1\text{–}2 \times 10^{-3}$	3×10^{-4}
	x_D	$2\text{–}3 \times 10^{-3}$	5×10^{-4}

CP Violation in mixing should be now better addressed

Other topics appear in the CDR

- spectroscopy (new states, tetraquarks)
- searches for non-standard light pseudoscalar Higgs and light dark matter at lower Υ(nS) resonances
- light quark studies using ISR (hadronic cross sections, for ex. input for $(g-2)_\mu$)

You are welcome to suggest your own preferred topic (and contribute the corresponding study!)

Conclusions

NP studies with precision flavour physics are possible at SuperB

Indirect NP searches with flavour explore a 2+ dim. space: NP scale + FV couplings

MFV provides the "worst case" for the values of FV couplings. Large $\tan\beta$ helps

NP at scales well beyond the LHC reach could give measurable effects at SuperB

If NP is found at LHC, SuperB can measure systematically the FV couplings

The physics case of SuperB is solidly established

Any of these or other NP signals could become real in the next few years!!