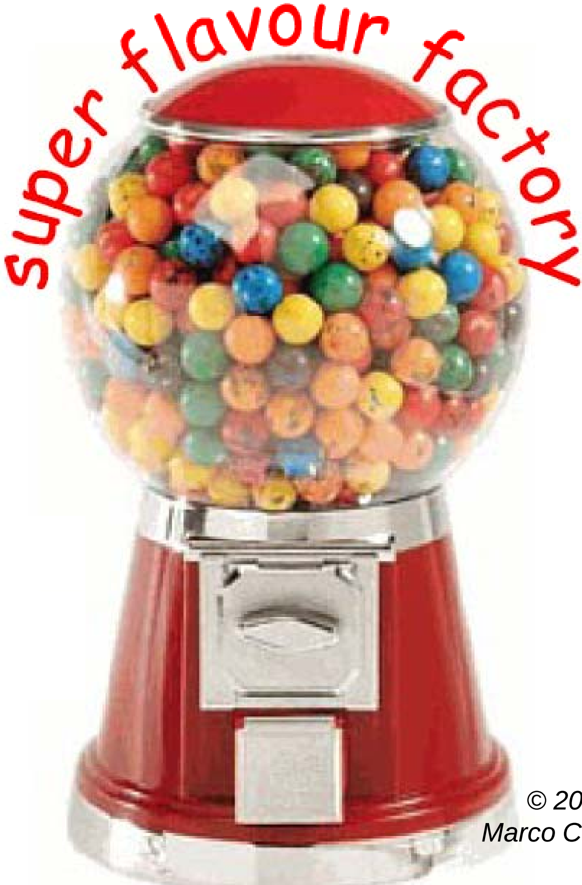
A Physics Potential of an e^+e^- Super(B)(Flavour) Factory



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FLAVOUR IN THE ERA OF THE LHC
a Workshop on the interplay of flavour and collider physics
Final Plenary meeting: CERN, March 26-28 2007

Two efforts :

Conceptual **D**esign **R**eport (**CDR**) for a Linear Super Flavour Factory — $75ab^{-1}$

Super B Factory – Update of the SUPERKEKB Physics case — $50ab^{-1}$

Both documents will be soon out.

Executive summary will be written for the Yellow Book

(These days we are mutually checking and studying two reports)

During the workshop quite a lot has been already said and commented by several speakers, concerning the potential of a SuperB :
D.Asner for charm
J.Berryhill for rare decays
M.Ciuchini for many things..
M.Rooney for τ
A.Buras for FCNC..
M.Hazumi for present status of B-factory and short term perspective..

To learn more about the two projets/their difference please listen the two following talks
M. Giorgi Linear Super Flavour Factory
K. Oide Super KEKB

B factories have shown that a variety of measurements can be performed in the clean environment.

By doing the work of extrapolating the existing measurements and the ones which will be possible with more statistics we observe that :

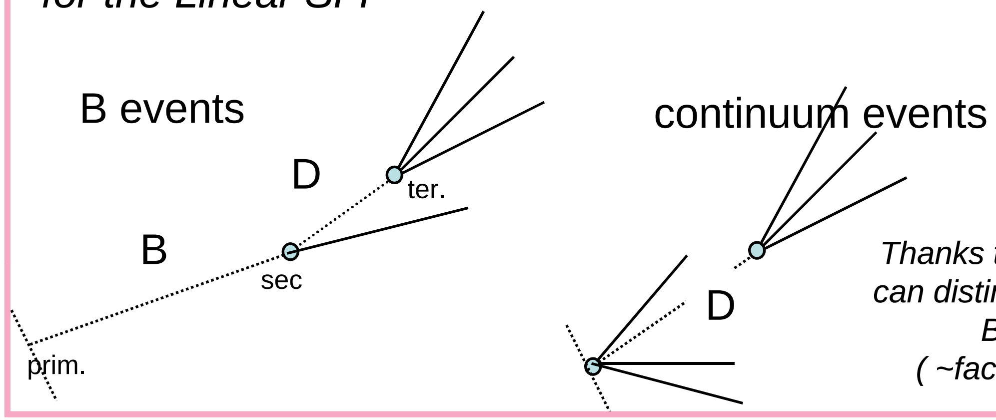
- **Several measurements are statistically limited and so it is worthwhile to collect >50ab^{-1}**

- **The systematic errors are very rarely irreducible and can almost on all cases be controlled with control samples.**

On top of it detector improvements can be crucial for some analyses.

Just one example for the Linear SFF

Not yet included in the extrapolations



Thanks to better vertex resolution we can distinguish on vertex requirements B vs continuum events (~factor 5 background rejection)

We concentrate on some topics

1) superb measurements related to **tree level/ ~tree level (some depending upon LCQD calculations)**

γ (DK), V_{ub}/V_{cb} [$\alpha(\pi\pi,\rho\pi,\pi\pi)$]

2) superb measurements very sensitive to **NP Physics**

sin(2β) (Peng.)
$A_{FB}(X_s l^+ l^-)$, $A_{FB}(K^*\gamma)$,
$A_{CP}(K^*\gamma)$, $A_{CP}(s\gamma)$,
$A_{CP}((s+d)\gamma)$
$B \rightarrow K^{(*)}\nu\nu$, LFV $\tau \rightarrow \mu\gamma$

3) several quantities **depending upon LCQD calculations**
If Lattice QCD Calculations improve as the related experimental quantities, these measurements will be extremely powerfull

$Br(B \rightarrow (\rho,\omega),\gamma)$

$Br(B \rightarrow l\nu)$, $Br(B \rightarrow D\tau\nu)$

4) <1% UT Fits for New Physics search (all the measurements mentioned before + others..)

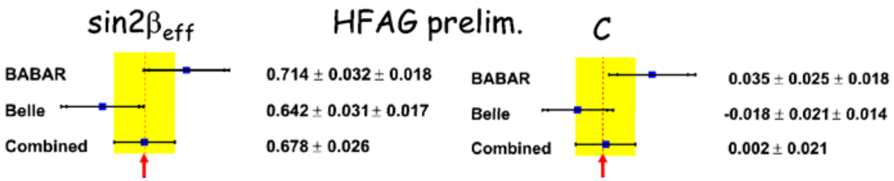
5) charm measurements

6) Specific run at the Υ(5S)

Experimental Reach

The angle β

Based on the present "savoir faire"

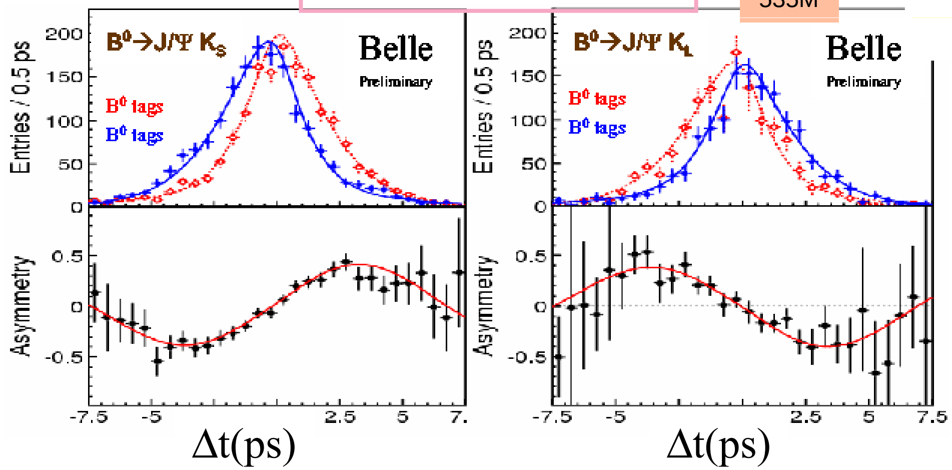


0.678 ± 0.026 0.002 ± 0.021

sin2β gives the best constraint on ρ–η plane
and the error can still be reduced

Golden $B^0 \rightarrow J/\psi K^0$

535M



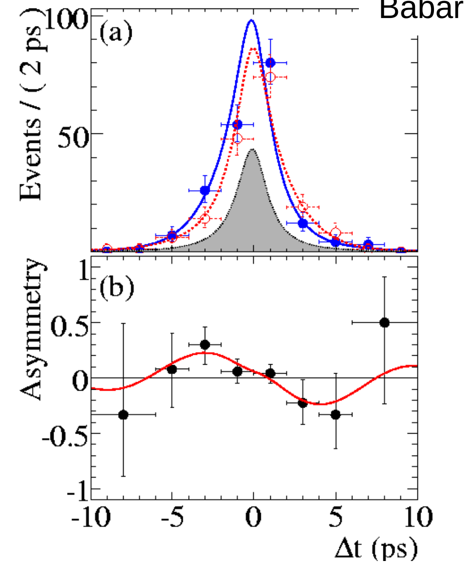
SuperB will be able to make complementary measurements (beyond $J/\psi K^0$) that help to ensure that the theoretical uncertainties are under control and to control them on data

Observable	B Factories (2 ab^{-1})	**SuperB**
$\sin(2\beta)$ $(J/\psi K^0)$	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

syst as today
0.012

Example other modes :
$B^0 \rightarrow D^0 h^0$

Babar



$S = +0.56 \pm 0.23 \pm 0.05$

$C = -0.23 \pm 0.16 \pm 0.04$

Important points :
- We know how to perform these analyses
- Very significant improvement from now→2ab^{-1}→ Superb luminosity

The angle α

Isospin analyses performed
at the B-factories
σ(α) @ 10^0

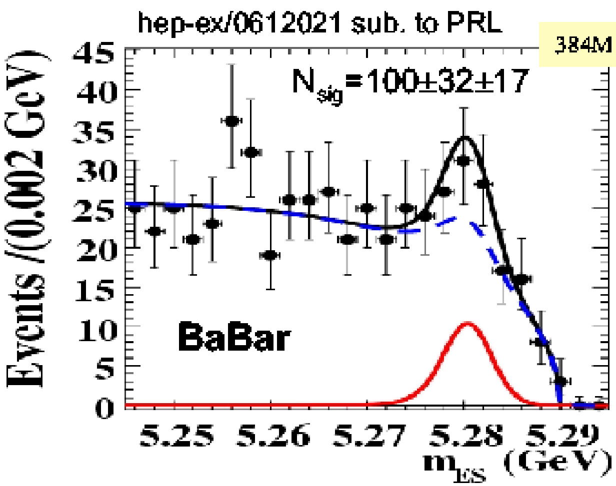
Some very important measurements
start to be possible only now with
about $0.5ab^{-1}$

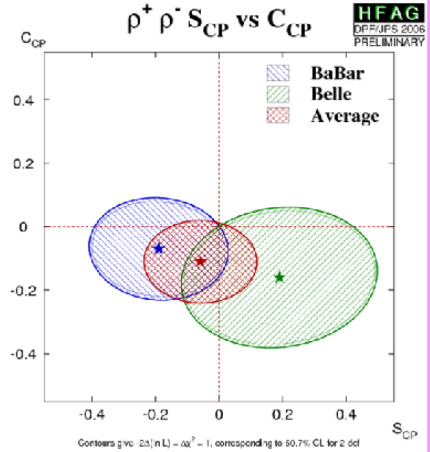
ρρ modes

$$Br(B \to \rho^0\rho^0) = (1.07 \pm 0.33 \pm 0.19)\times 10^6$$

3.5σ evidence

Important measurement because it gives
the contributions of Penguins diagram





consistent with no CP violation
α_{eff}~90° (0/180)°

Each of ππ,ρπ,ρρ analysis will be allow to get σ(α)~2 degrees
It allow consistency checks and to control theoretical uncertainties on data

Observable	B Factories (2 ab^{-1})	**SuperB**
$\alpha\ (B \to \pi\pi)$	$\sim 16°$	3°
$\alpha\ (B \to \rho\rho)$	$\sim 7°$	1–2° (*)
$\alpha\ (B \to \rho\pi)$	$\sim 12°$	2°
α (combined)	$\sim 6°$	1–2° (*)

(*) theoretical limited

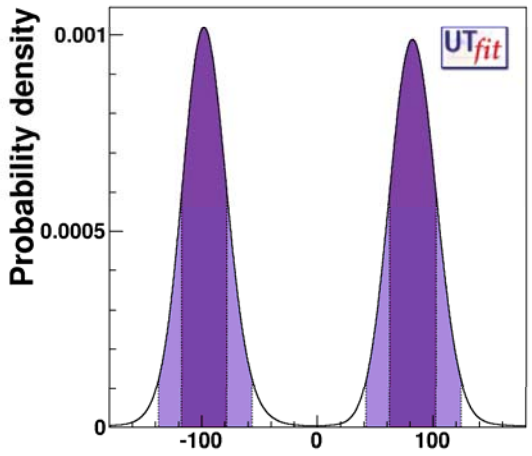
σ(α)~1° possible

The angle γ

Best measurements from Dalitz analysis with $D^0 \rightarrow K_s\pi\pi$

$\gamma = (92 \pm 41_{stat} \pm 10_{syst} \pm 13_{Dalitz})^o$ BaBar

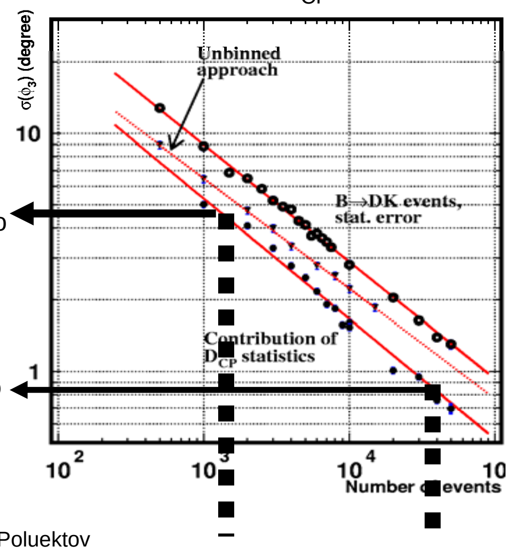
$\gamma = (53^{+15}_{-18\,stat} \pm 3_{syst} \pm 9_{Dalitz})^o$ Belle



$\gamma = (82 \pm 20)^o$

The model error can be reduced by running at threshold

Error vs D_{CP} statistics



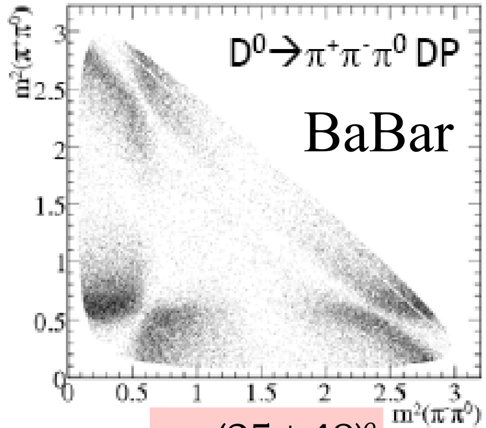
$(4\text{-}5)^o$

$(<1)^o$

750pb^{-1} 20fb^{-1}

Bondar Poluektov
hep-ph/0510246

New D^0 decays starting to be explored



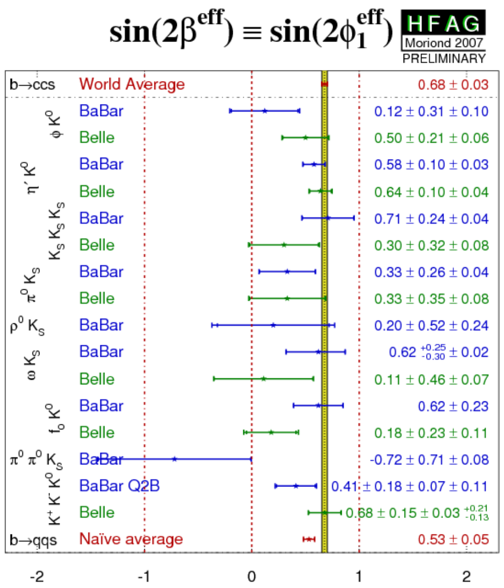
$\gamma = (25 \pm 48)^o$

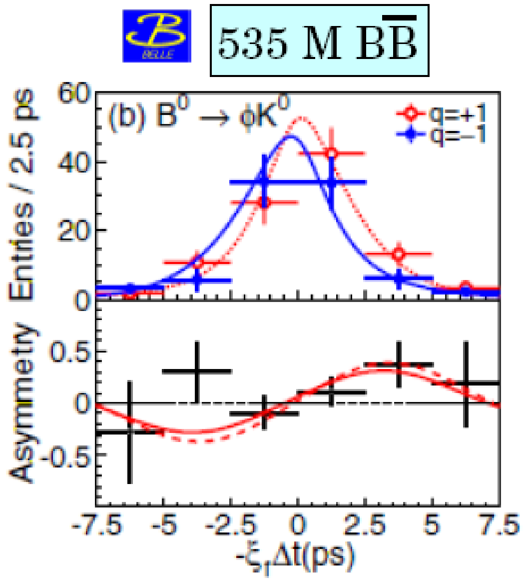
Many independent methods GLW, ADS, Dalitz, with many different decay channels

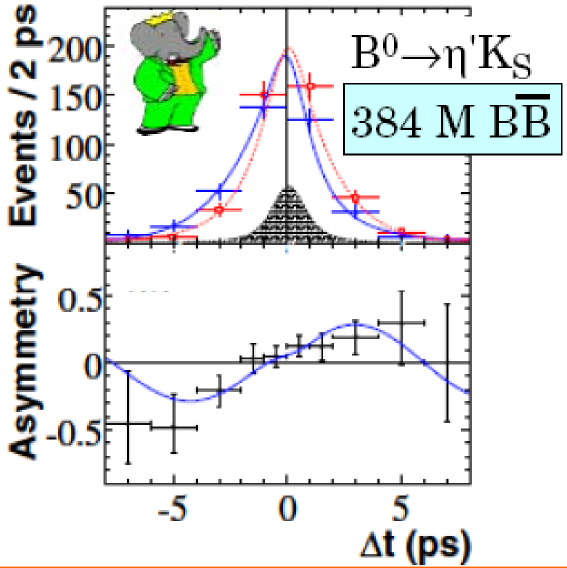
Observable	B Factories (2 ab^{-1})	**SuperB**
γ ($B \rightarrow DK$, $D \rightarrow CP$ eigenstates)	$\sim 15°$	$2.5°$
γ ($B \rightarrow DK$, $D \rightarrow$ suppressed states)	$\sim 12°$	$2.0°$
γ ($B \rightarrow DK$, $D \rightarrow$ multibody states)	$\sim 9°$	$1.5°$
γ ($B \rightarrow DK$, combined)	$\sim 6°$	1–$2°$
$2\beta + \gamma$ ($D^{(*)\pm}\pi^\mp$, $D^\pm K^0_S\pi^\mp$)	$20°$	$5°$

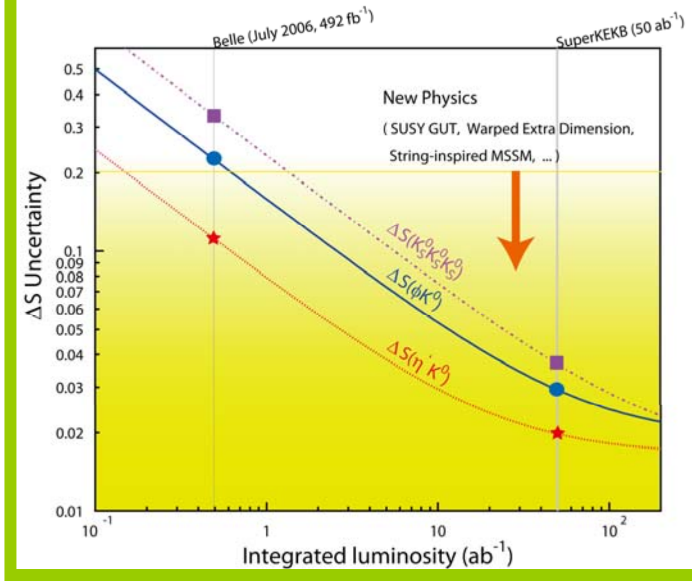
σ(γ)~1° possible

sin2β from “s Penguins”…









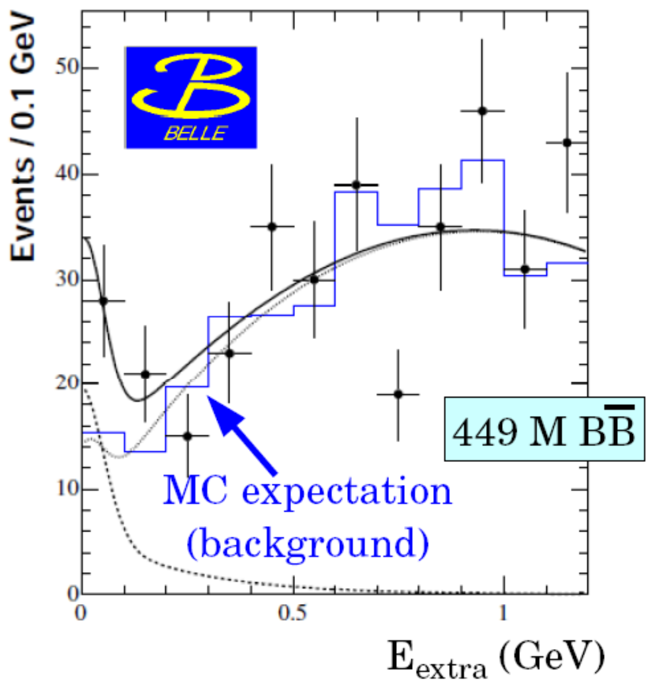
Many channels can be measured with ΔS~(0.01-0.04)

Observable	B Factories ($2\ \mathrm{ab}^{-1}$)	**SuperB**	
$S(\phi K^0)$	0.13	0.02 (∗)	[0.030]
$S(\eta' K^0)$	0.05	0.01 (∗)	[0.020]
$S(K^0_s K^0_s K^0_s)$	0.15	0.02 (∗)	[0.037]
$S(K^0_s \pi^0)$	0.15	0.02 (∗)	[0.042]
$S(\omega K^0_s)$	0.17	0.03 (∗)	
$S(f_0 K^0_s)$	0.12	0.02 (∗)	

(*) theoretical limited

leptonic decay B→lν

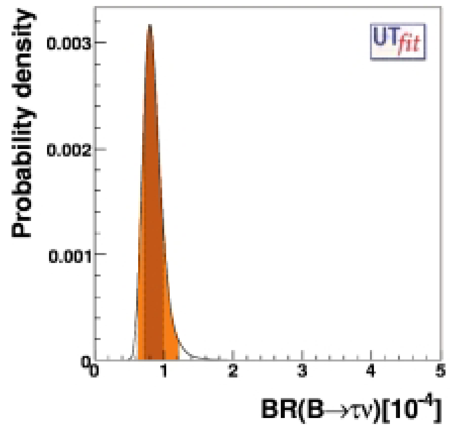
Milestone :
<u>First leptonic decay seen on B meson</u>



Exp. likelihood BABAR+BELLE
BR(B → τ ν) = (1.31 ± 0.48) 10^{-4}

First test can be done, not yet precise →

SM expectation



BR(B → τ ν) = (0.85 ± 0.13) 10^{-4}

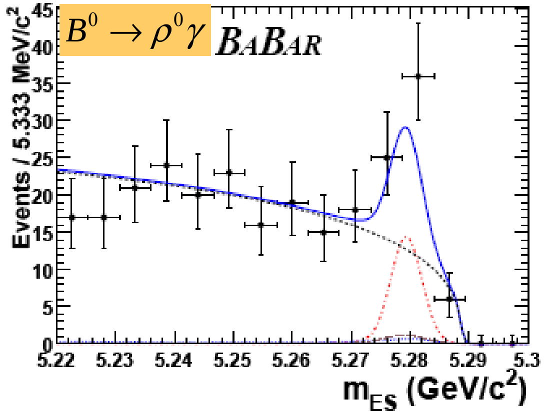
Observable	B Factories (2 ab^{-1})	**SuperB**
$\mathcal{B}(B \to \tau\nu)$	20%	4% (†) [3%]
$\mathcal{B}(B \to \mu\nu)$	visible	5%
$\mathcal{B}(B \to D\tau\nu)$	10%	2%

(+) systematically limited

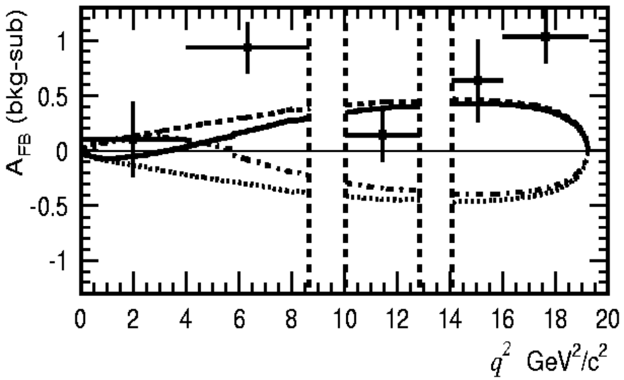
Br(B→τν) up to 3-4% (below limited by systematics)
Br(B→μν) can be measured with the same precision not limited by syst.

Radiative B decays

- many measurements on B→sγ
- measurements of Br on B→ργ
- measurement of A_{CP} on exclusive and inclusive modes



-Measurements of Br done
-We start to perform A^{FB} measur.



Observable	B Factories (2 ab^{-1})	**SuperB**
$\mathcal{B}(B \to \rho\gamma)$	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 (†) [0.05]
$A_{CP}(b \to (s+d)\gamma)$	0.03	0.006 (†)
$S(K_S^0\pi^0\gamma)$	0.15	0.02 (∗) [0.03]
$S(\rho^0\gamma)$	possible	0.10

(+) systematically limited *(*) theoretically limited*

Significant improvement on b→dγ
A_{CP} in inclusive decay at ~0.5% ! (SM~0.5%)

Observable	B Factories (2 ab^{-1})	**SuperB**
$A_{CP}(B \to K^*\ell\ell)$	7%	1%
$A^{FB}(B \to K^*\ell\ell)s_0$	25%	9%
$A^{FB}(B \to X_s\ell\ell)s_0$	35%	5%
$\mathcal{B}(B \to K\nu\overline{\nu})$	visible	20%
$\mathcal{B}(B \to \pi\nu\bar{\nu})$	–	possible

CP and FB asymetries in sll exclusive and inclusive decays at few per cent

Could the SuperB
be a
Super Flavour Factory ?

Which is the interest ?

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°

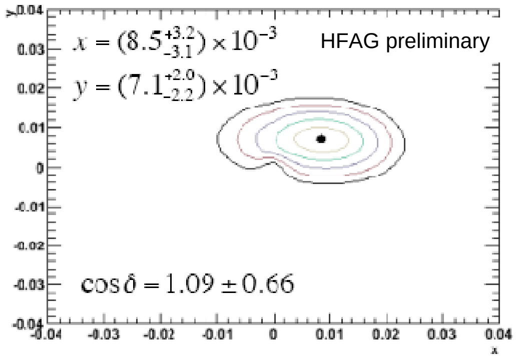
Rare decays FCNC down to 10^{-8}

@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}
$D^0 \to K_S^0 e^+e^-$, $D^0 \to K_S^0\mu^+\mu^-$	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}
$D^0 \to K_S^0 e^\pm\mu^\mp$	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}	2–3×10^{-3}	5×10^{-4}
$D^0 \to K^+\pi^-$	y'_D	2–3×10^{-3}	7×10^{-4}
	x'^2_D	1–2×10^{-4}	3×10^{-5}
$D^0 \to K_S^0\pi^+\pi^-$	y_D	2–3×10^{-3}	5×10^{-4}
	x_D	2–3×10^{-3}	5×10^{-4}
Average	y_D	1–2×10^{-3}	3×10^{-4}
	x_D	2–3×10^{-3}	5×10^{-4}

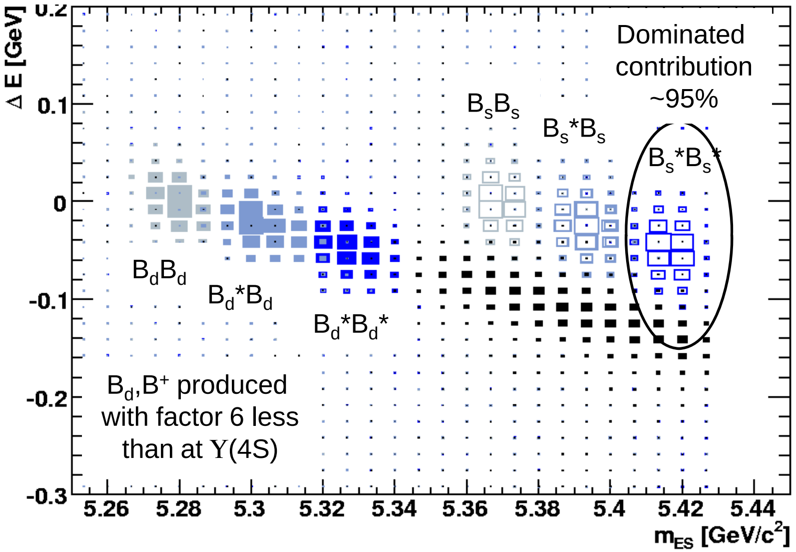
CP Violation in mixing should be now better addressed

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

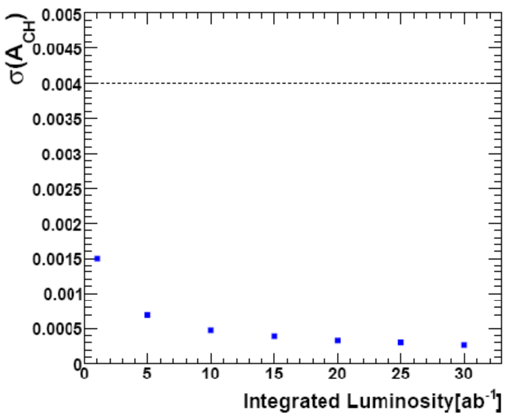
Observable	Error with 1 ab^{-1}	Error with 30 ab^{-1}
$\Delta\Gamma$	0.16 ps^{-1}	0.03 ps^{-1}
Γ	0.07 ps^{-1}	0.01 ps^{-1}
β_s from angular analysis	20°	8°
A^s_{SL}	0.006	0.004
A_{CH}	0.004	0.004
$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	$< 8 \times 10^{-9}$
$\|V_{td}/V_{ts}\|$ *	0.08	0.017
$\mathcal{B}(B_s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

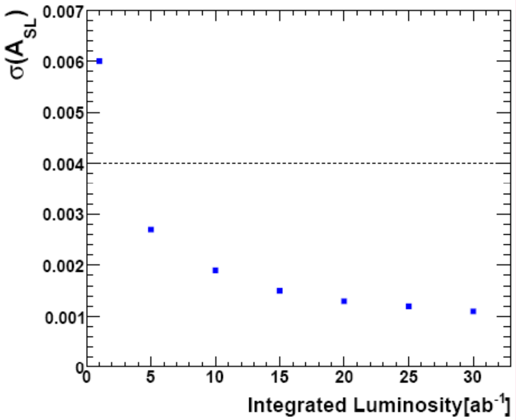
*: $\mathcal{B}(B^0_s \to K^{*0}\gamma)/\mathcal{B}(B^0_d \to K^{*0}\gamma)$.

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

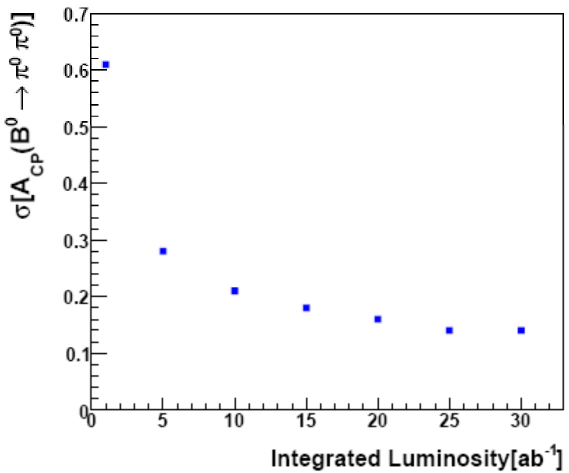


Integrated quantities A_{SL} and A_{CH} at less than 0.5%
Even a run at 1ab^{-1} will give less 1% error.





BB from B*B produced in C=+1 after B→Bγ decay → some sensitivity to S term in time integrated CP asym.



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

Estimates of error for 2015

Hadronic matrix element	Current lattice error	6 TFlop Year	60 TFlop Year	1-10 PFlop Year
$f_+^{K\pi}(0)$	0.9% (22% on $1-f_+$)	0.7% (17% on $1-f_+$)	0.4% (10% on $1-f_+$)	**< 0.1% (2.4% on $1-f_+$)**
$\hat{B}_K$	11%	5%	3%	**1%**
f_B	14%	3.5 - 4.5%	2.5 - 4.0%	**1 – 1.5%**
$f_{Bs}B_{Bs}^{1/2}$	13%	4 - 5%	3 - 4%	**1 – 1.5%**
ξ	5% (26% on ξ-1)	3% (18% on ξ-1)	1.5 - 2 % (9-12% on ξ-1)	**0.5 – 0.8 % (3-4% on ξ-1)**
$\Phi_{B \to D/D^* l\nu}$	4% (40% on $1-\Phi$)	2% (21% on $1-\Phi$)	1.2% (13% on $1-\Phi$)	**0.5% (5% on $1-\Phi$)**
$f_+^{B\pi}, \ldots$	11%	5.5 - 6.5%	4 - 5%	**2 – 3%**
$T_1^{B\to K^*/\rho}$	13%	----	----	**3 – 4%**

Many of the following simulations are performed using Vittorio Lubicz’s numbers

Phenomenological Impact

The problem of particle physics today is :
where is the NP scale $\Lambda \sim 0.5, 1 \ldots 10^{16}$ TeV

The quantum stabilization of the Electroweak Scale
suggest that $\Lambda \sim 1$ TeV
LHC will search on this range

What happens if the NP scale is at 2-3..10 TeV
…naturalness is not at loss yet…

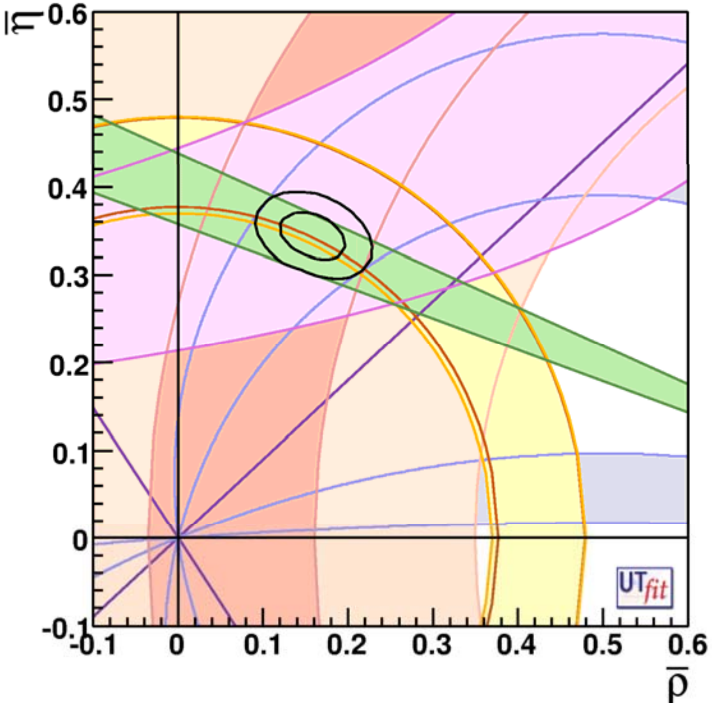
Flavour Physics explore also this range

$$\frac{|\delta_{bq}|}{\Lambda_{eff}}$$

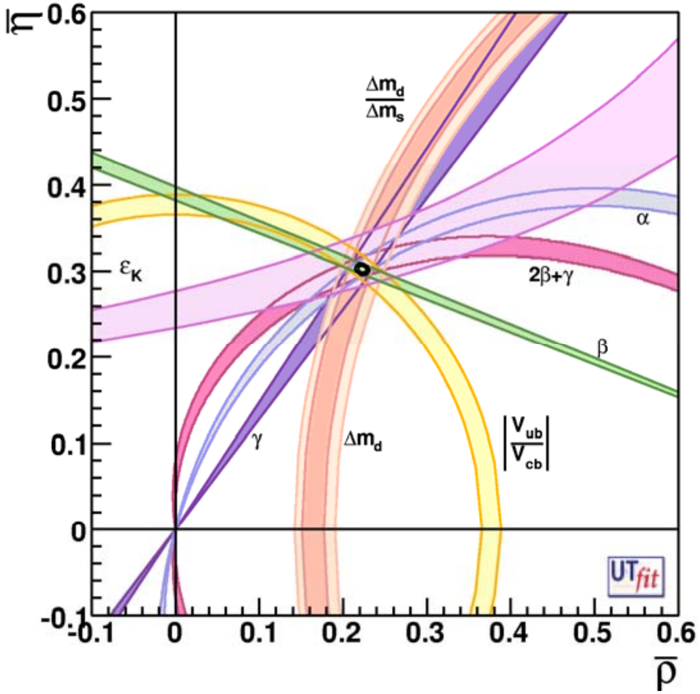
We want to perform flavour measurements such that :
- if NP particles are discovered at LHC we are able to study the flavour structure of the NP
- we can explore NP scale beyond the LHC reach

In SM

Today



SuperB+Lattice improvements



ρ = 0.163 ± 0.028
η = 0.344± 0.016

ρ = ± 0.0028
η = ± 0.0024

about 10 times better (not all measurements yet included…)

Two crucial questions :

Can NP be flavour blind ?

No : NP couples to SM which violates flavour

Can we define a “worst case” scenario

Yes : the class of model with Minimal Flavour Violation (**MFV**),
namely : no new sources of flavour and CP violation
and so : NP contributions governed by SM Yukawa couplings.

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

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

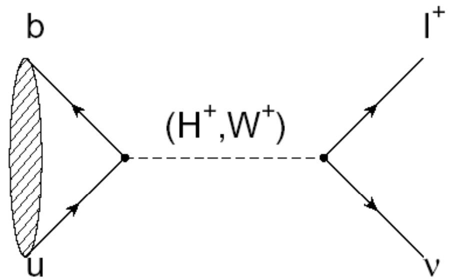
Today
Λ(MFV) > 2.3Λ_0 @95C.L.

NP masses >200GeV

SuperB
Λ(MFV) >~6Λ_0 @95C.L.

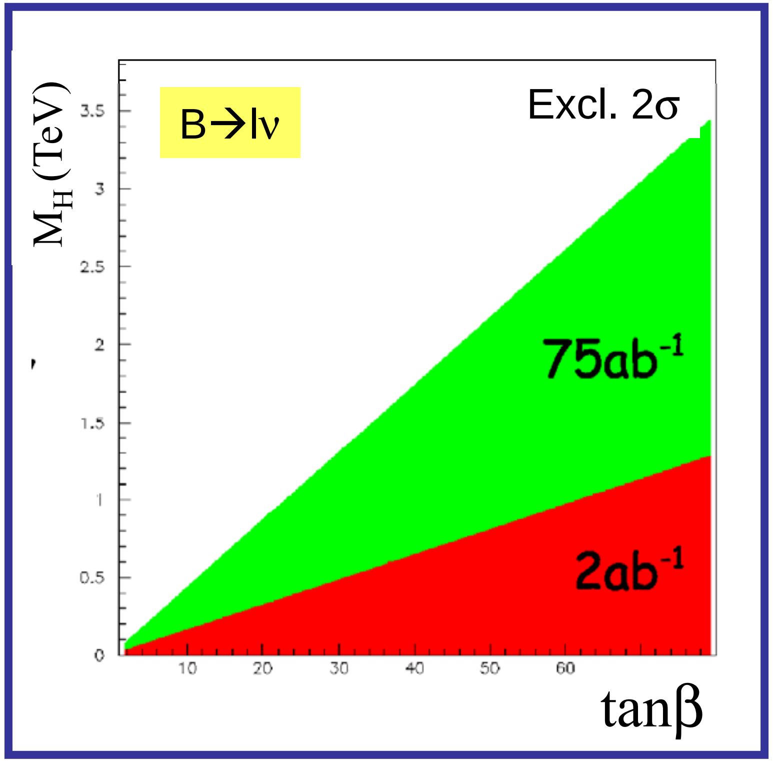
NP masses >600GeV

Higgs-mediated NP in MFV at large tanβ

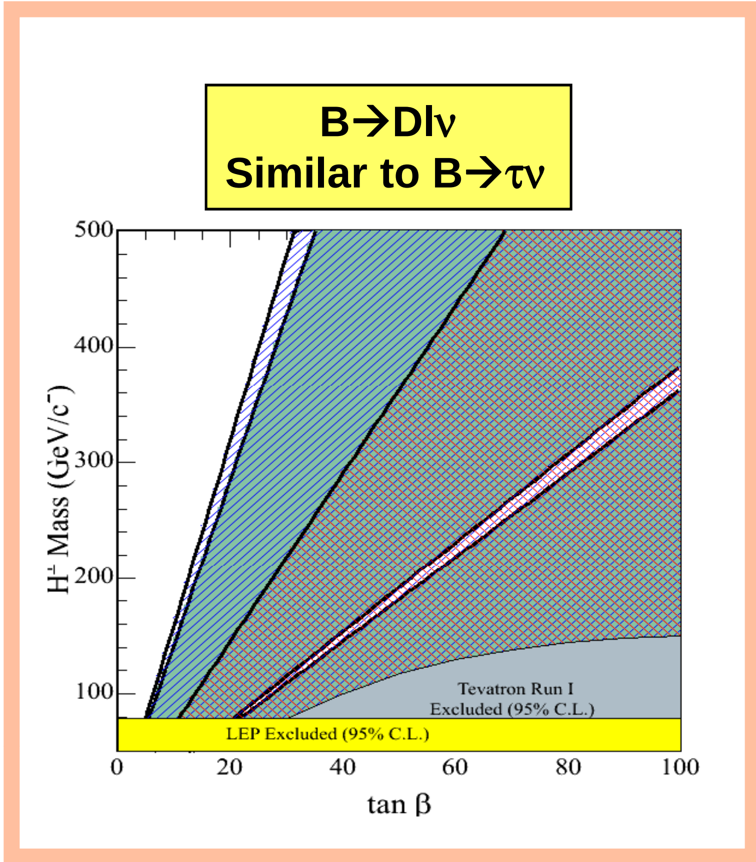


$$BR(B\to\tau\nu) = BR_{SM}(B\to\tau\nu)\left(1-\frac{m_B^2}{M_H^2}\tan^2\beta\right)^2$$

Similar formula in MSSM.



2ab⁻¹	SuperB
M_H~0.4-0.8 TeV for tanβ~30-60	M_H~1.2-2.5 TeV for tanβ~30-60

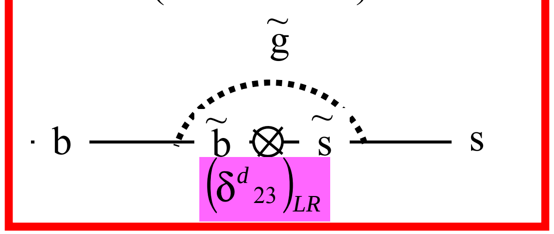


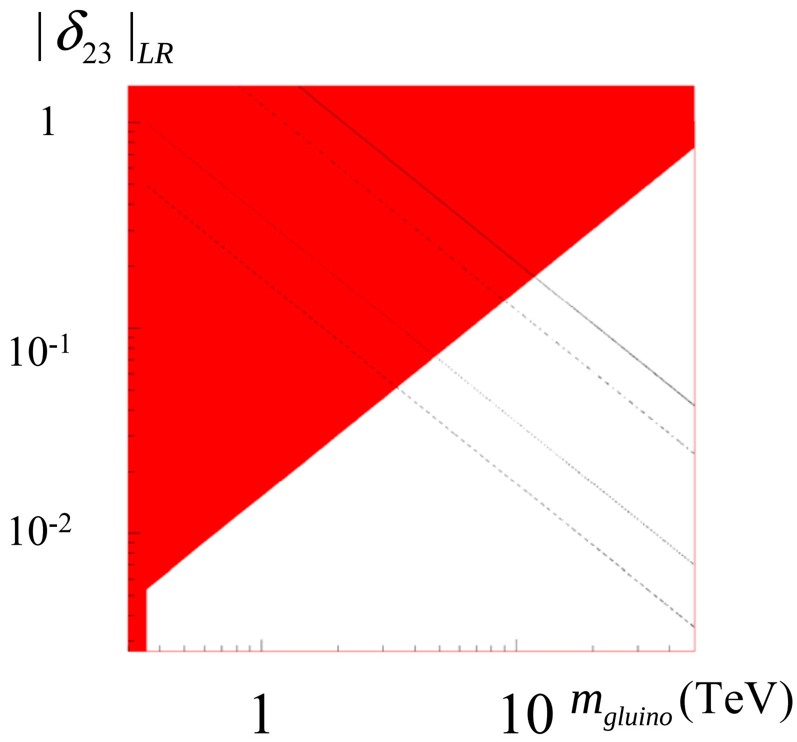
MSSM+generic soft SUSY breaking terms

Flavour-changing NP effects in the squark propagator
→ NP scale SUSY mass $\tilde{m} \sim m_{\tilde{g}}$

→ flavour-violating coupling $(\delta_{ij}^{q})_{AB} \equiv \frac{(M_{ij}^{2})_{AB}^{q}}{\tilde{m}^{2}}$

New Physics contribution
(2-3 families)

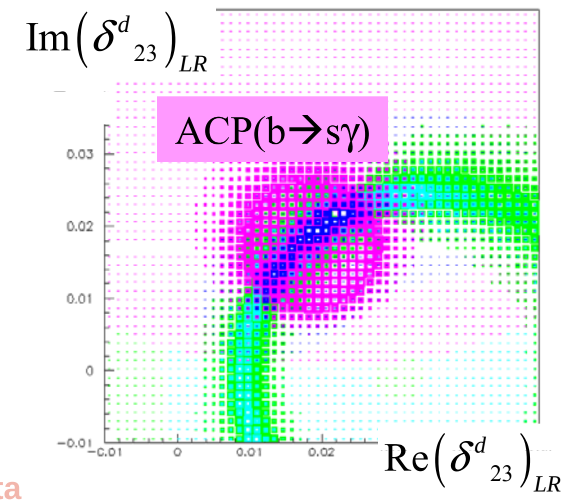




With the today precision we do not have 3σ exclusion

In the red regions the δ are measured with a significance >3σ away from zero

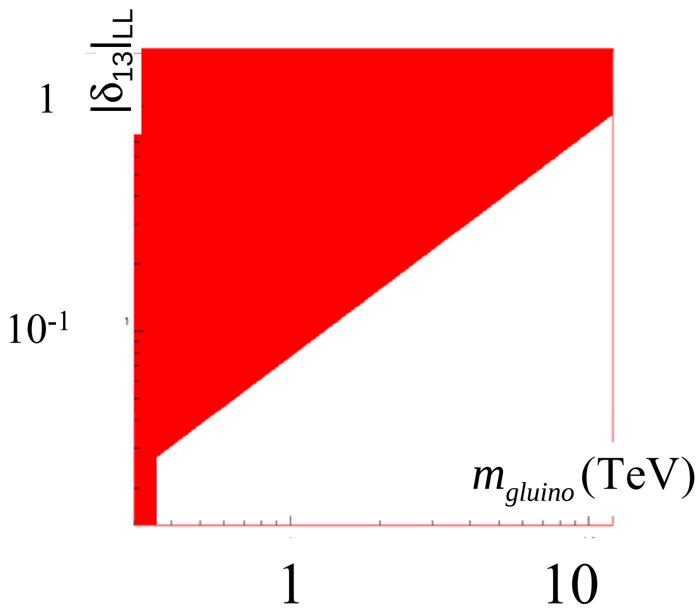
In this case the main constraints are b→sγ



ACP magenta
Br(sg) green
Br(sll) cyan
All constr. blue

Today we would have magenta contour covering all the space

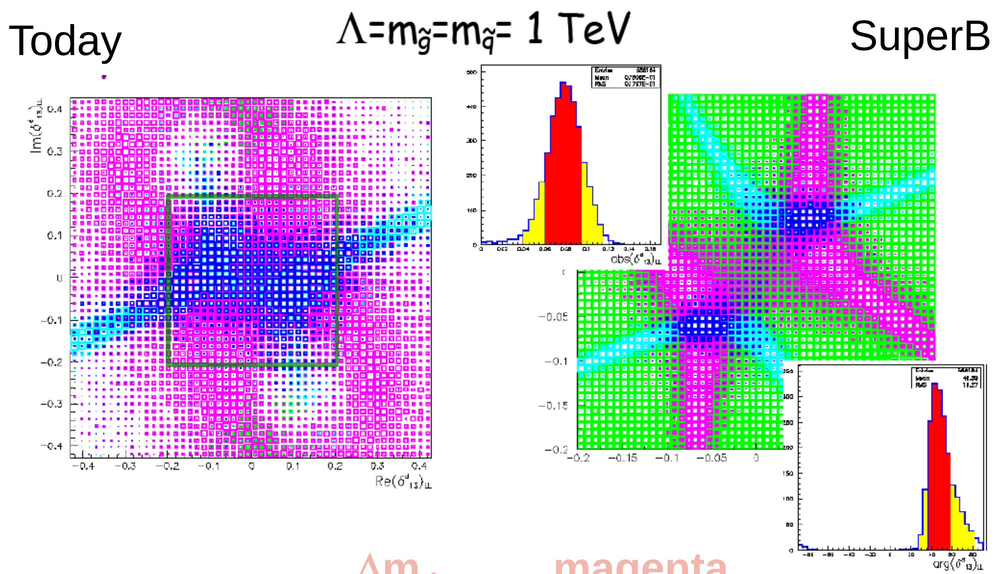
New Physics contribution
(1-3 families)



With the today precision we do not have 3σ exclusion

In the red regions the δ are measured with a significance >3σ away from zero

Example on how NP parameters can be measured



Δm_d	magenta
A_{SL}	green
β	cyan
All constr.	**blue**

Let's be more quantitative	superB	general MSSM	high-scale MFV
$\left\|\left(\delta^d_{13}\right)_{LL}\right\|\ (LL \gg RR)$	$1.8 \cdot 10^{-2} \frac{m_{\tilde q}}{(350\text{GeV})}$	1	$\sim 10^{-3} \frac{(350\text{GeV})^2}{m^2_{\tilde q}}$
$\left\|\left(\delta^d_{13}\right)_{LL}\right\|\ (LL \sim RR)$	$1.3 \cdot 10^{-3} \frac{m_{\tilde q}}{(350\text{GeV})}$	1	–
$\left\|\left(\delta^d_{13}\right)_{LR}\right\|$	$3.3 \cdot 10^{-3} \frac{m_{\tilde q}}{(350\text{GeV})}$	$\sim 10^{-1} \tan\beta \frac{(350\text{GeV})}{m_{\tilde q}}$	$\sim 10^{-4} \tan\beta \frac{(350\text{GeV})^3}{m^3_{\tilde q}}$
$\left\|\left(\delta^d_{23}\right)_{LR}\right\|$	$1.0 \cdot 10^{-3} \frac{m_{\tilde q}}{(350\text{GeV})}$	$\sim 10^{-1} \tan\beta \frac{(350\text{GeV})}{m_{\tilde q}}$	$\sim 10^{-3} \tan\beta \frac{(350\text{GeV})^3}{m^3_{\tilde q}}$

How to read this table, two examples.

At the SuperB we can set a limit on the coupling at $1.8\times10^{-2}\frac{m_q}{350GeV}$

The natural coupling would be 1

$\delta_{LL}(LL >> RR)$ ⟶ we can test scale up to $\frac{350GeV}{1.8\times10^{-2}} \sim 20TeV$

$\delta_{LL}(LL \sim RR)$ ⟶ we can test scale up to $\frac{350GeV}{1.3\times10^{-3}} \sim 270TeV$

SuperB will probe up to >100 TeV for arbitrary flavour structure!

All this number are a factor ~10 better than the present ones

These evaluations do not agree with those given in SuperKEKB : disussion undergoing

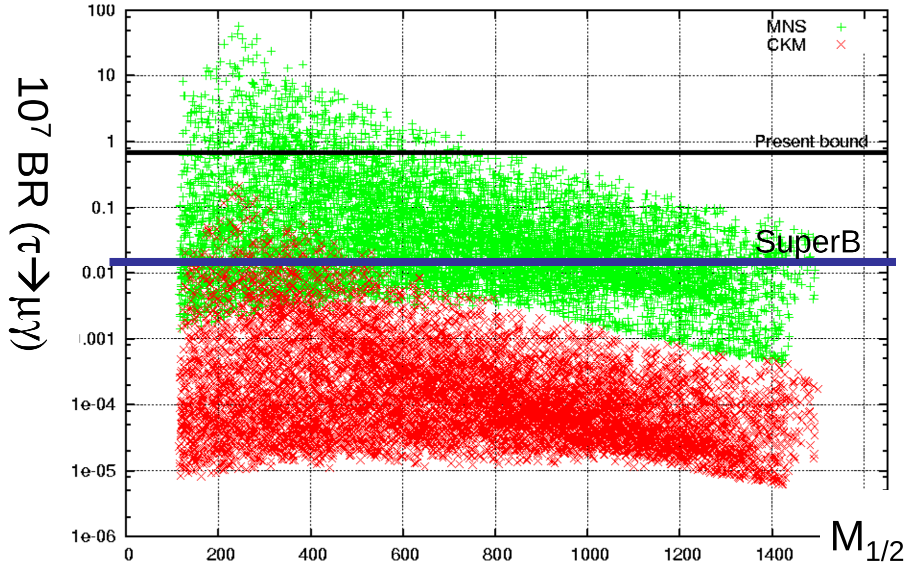
τ physics just discussed this morning by M. Roney

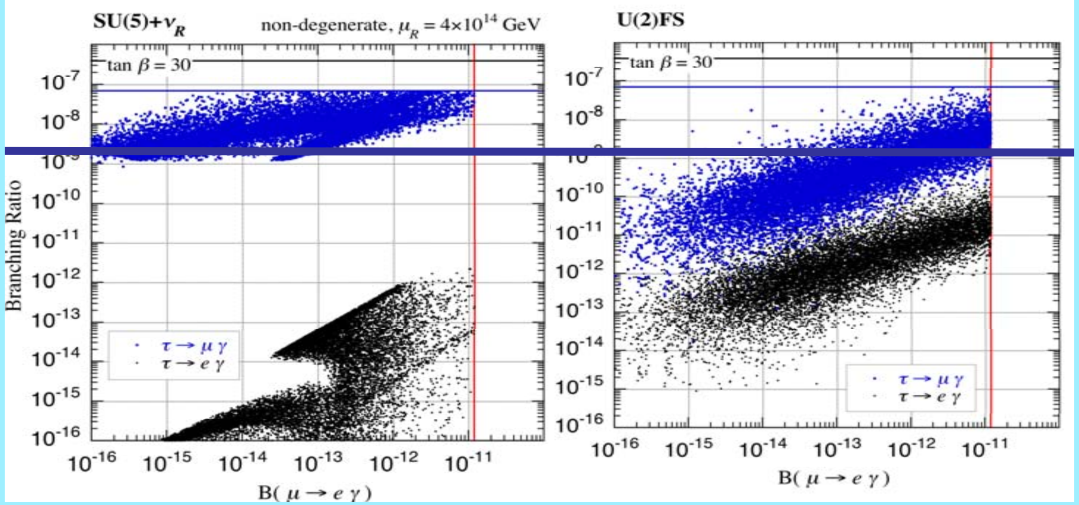
$B(\tau\to\mu\gamma):B(\tau\to e\gamma):B(\mu\to e\gamma) \sim \lambda^{-6}:\lambda^{-4}:1 \sim 10^4:500:1$ LFV from CKM

SSF <-> MEG

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

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}





LVF and Littlest Higgs Model

decay	$f=500\text{GeV}$
$\tau\to e\gamma$	$1\cdot10^{-8}$
$\tau\to\mu\gamma$	$2\cdot10^{-8}$
$\tau^-\to e^-e^+e^-$	$2\cdot10^{-8}$
$\tau^-\to\mu^-\mu^+\mu^-$	$3\cdot10^{-8}$

ratio	LHT	MSSM (dipole)	MSSM (Higgs)
$\frac{Br(\tau^-\to e^-e^+e^-)}{Br(\tau\to e\gamma)}$	$0.4\ldots2.3$	$\sim1\cdot10^{-2}$	$\sim1\cdot10^{-2}$
$\frac{Br(\tau^-\to\mu^-\mu^+\mu^-)}{Br(\tau\to\mu\gamma)}$	$0.4\ldots2.3$	$\sim2\cdot10^{-3}$	$0.06\ldots0.1$

Summary

SFF can perform many measurements at <1% level of precision

Precision on CKM parameters will be improved by more than a factor 10

NP will be studied (measuring the couplings) if discovered at LHC

if NP is not seen at the TeV by LHC, SFF is the way of exploring
NP scales of the several TeV (in some scenario several (>10)TeV..)

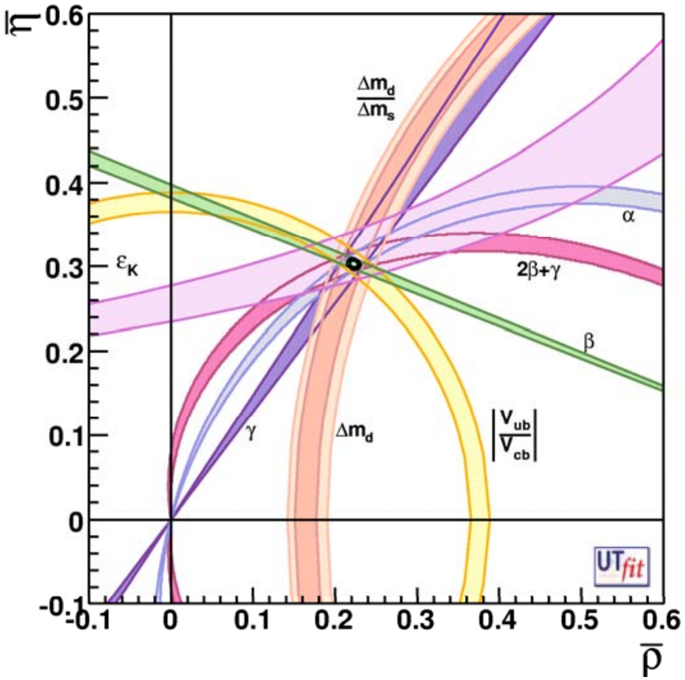
… and do not forget… **SFF** can be a **Super τ-charm factory**…

We need to go on in measuring precisely many different quantites

$A_{CP}(B \to X\gamma)$
$A_{FB}(B \to Xll)$
CPV in CF and DCS D decays
$Br(\tau \to \mu\gamma)$
……

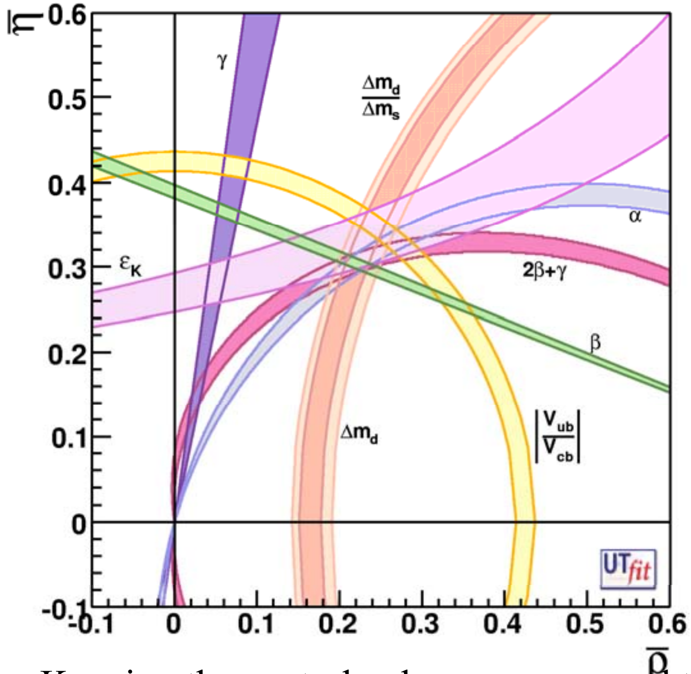
CKM angles α,β,γ
$Br(B \to \tau\nu)$ and $B \to Dl\nu$
$|V_{ub}|,|V_{cb}|$
radiative decays : $Br(B \to \rho\gamma, K^*\gamma)$
many other measurements…

Could be a nightmare….



Adjusting the central values so that they are all compatible

I'm sure..will be a dream…



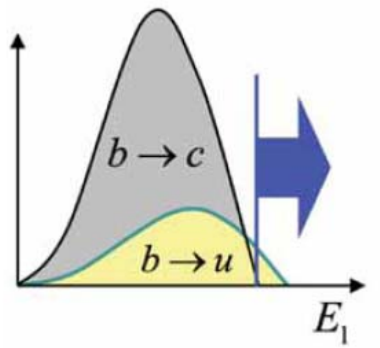
Keeping the central values as measured today with errors at the SuperB

BACKUP MATERIAL

Progress on V_{ub}..

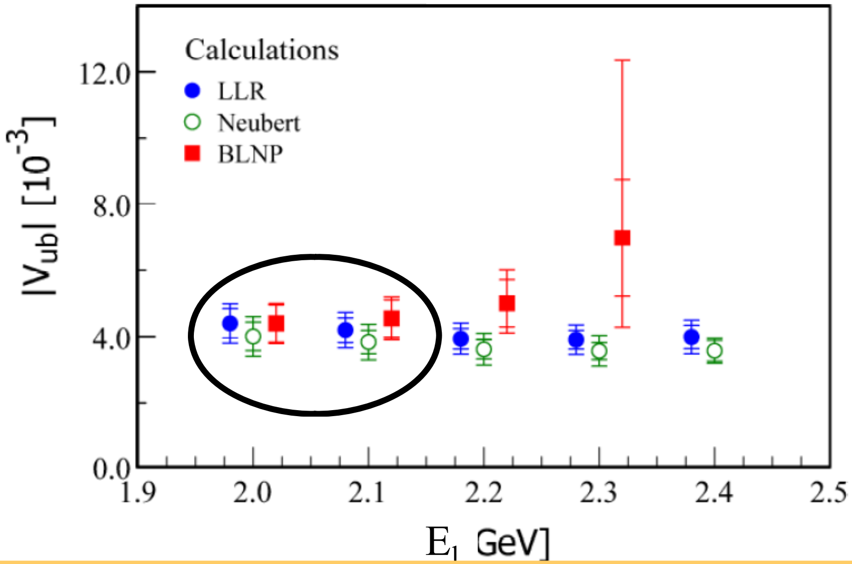
$B \rightarrow X_u \, l \, \nu$

Inclusive : improving analyses and improving the control of the theory vs cuts



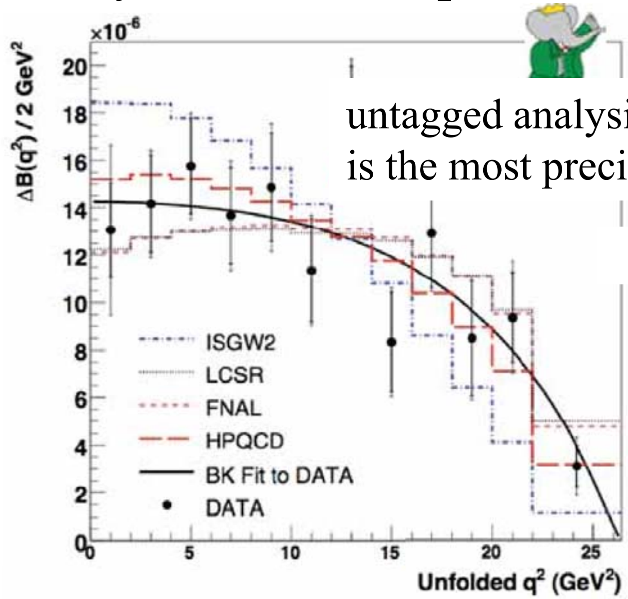
Br ~ $|V_{ub}|^2$ in a limited space phase region…

Using Babar E_l, $(X_s\gamma)$



$B \rightarrow \pi \, l \, \nu$

Exclusive :
we start to have quite precise analysis of Br vs q^2



untagged analysis is the most precise

Important that we measure at high q^2 where Lattice QCD calculates better.

$|V_{ub}| = (4.1 \pm 0.2_{st} \pm 0.20_{sys}{}^{+0.6}{}_{-0.4FF}) 10^{-3}$

exclusive decays, untagged using HPQCD, q^2>16 GeV^2

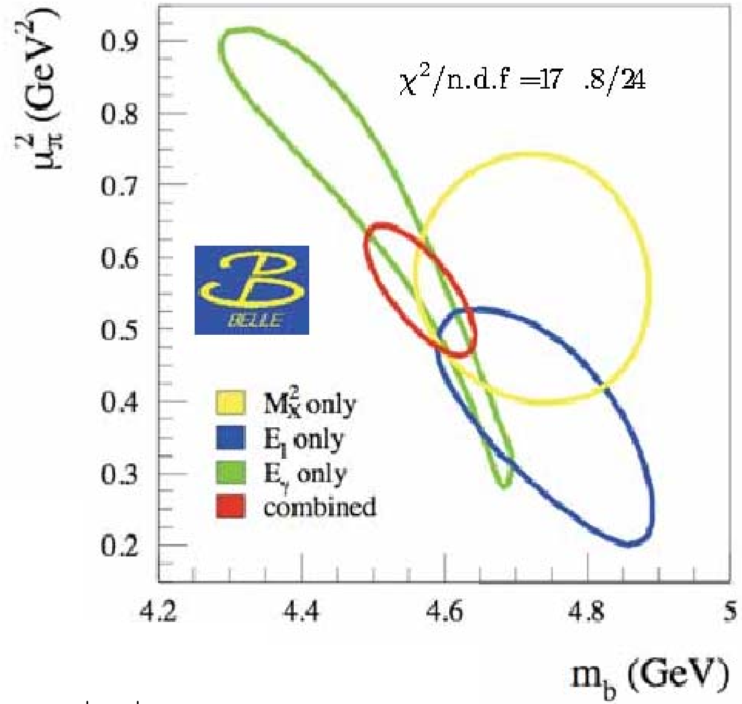
$|V_{ub}| = (4.40 \pm 0.30 \pm 0.41 \pm 0.23)\ 10^{-3}$

inclusive decays, reduced model dependence

Confirming disagreement…

Precision measurements of $|V_{cb}|$

Inclusive V_{cb} still progress…



$$|V_{cb}| = (41.93 \pm 0.65_{fit} \pm 0.07_{\alpha_s} \pm 0.67_{theo.})10^{-3}$$

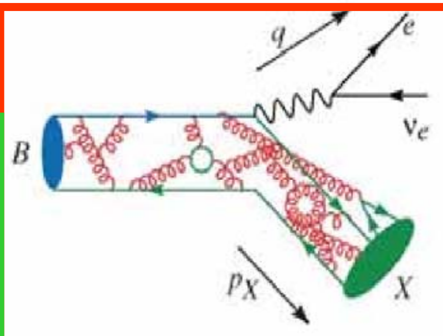
$$m_b = (4.564 \pm 0.076_{fit} \pm 0.003_{\alpha_s})GeV$$

$$m_c = (1.105 \pm 0.116_{fit} \pm 0.005_{\alpha_s})GeV$$

$$Br_{cl\nu} = (10.590 \pm 0.164_{fit} \pm 0.006_{\alpha_s})\%$$

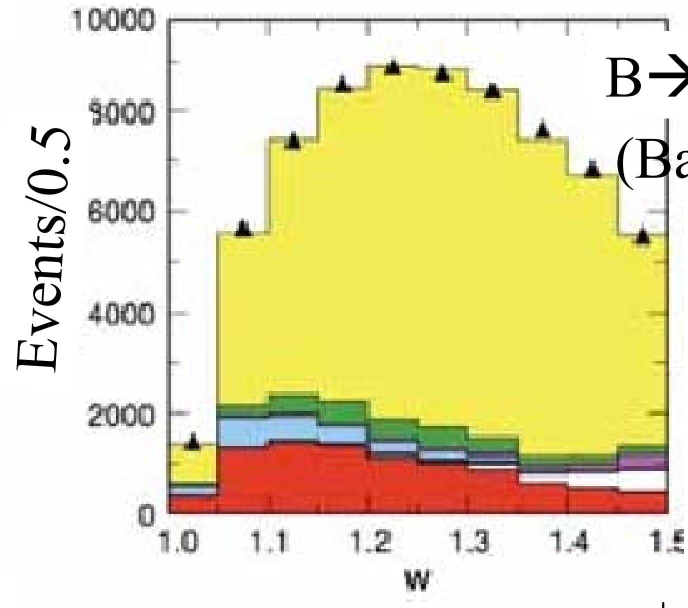
BaBar/CLEO/CDF/DELPHI
Kinetic scheme

$$|V_{cb}| = (41.96 \pm 0.23_{fit} \pm 0.35_{\alpha_s} \pm 0.59_{theo.})10^{-3}$$



Essential point is to control /"measure" the effects of strong interaction

Same for exclusive..



here we extract : $F(1)|V_{cb}|$

limiting factor F(1)

Study on charm sector help in the understanding of strong dynamics

Rare decays : SuperB can cover all channels mentionned but $B_s \rightarrow \mu\mu$

Unless we perform
a long run at the U5S

B→τν at 4%

B→μν at 5%

CP asymetries in radiative exclusive and inclusive decays at a fraction of 1%

CP and FB asymetries in sll exclusive and inclusive decays at few per cent

Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab
$\mathcal{B}(B \to \tau\nu)$	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	0.006 (†)
$S(K_S^0\pi^0\gamma)$	0.15	0.02 (∗)
$S(\rho^0\gamma)$	possible	0.10
$A_{CP}(B \to K^*\ell\ell)$	7%	1%
$A^{FB}(B \to K^*\ell\ell)s_0$	25%	9%
$A^{FB}(B \to X_s\ell\ell)s_0$	35%	5%
$\mathcal{B}(B \to K\nu\bar{\nu})$	visible	20%
$\mathcal{B}(B \to \pi\nu\bar{\nu})$	–	possible

13% 2fb1
Only bb back.
Linear fit

Transv amplit. ??

18% for 50ab-1 in Jeff

Fit in a NP model independent approach

$\Delta F=2$

Parametrizing NP physics in $\Delta F=2$ processes

$$C_q e^{2i\varphi_d} = \frac{Q^{NP}_{\Delta B=2} + Q^{SM}_{\Delta B=2}}{Q^{SM}_{\Delta B=2}}$$

→

$$\Delta m_d^{EXP} = C_q \Delta m_d^{SM}$$

$$A_{CP}(J/\Psi K^0) = \sin(2\beta + 2\phi_d)$$

$$\alpha^{EXP} = \alpha^{SM} - \phi_d$$

$$|\varepsilon_K|^{EXP} = C_\varepsilon |\varepsilon_K|^{SM}$$

No new physics
$C=1$ $\varphi=0$

Constraints

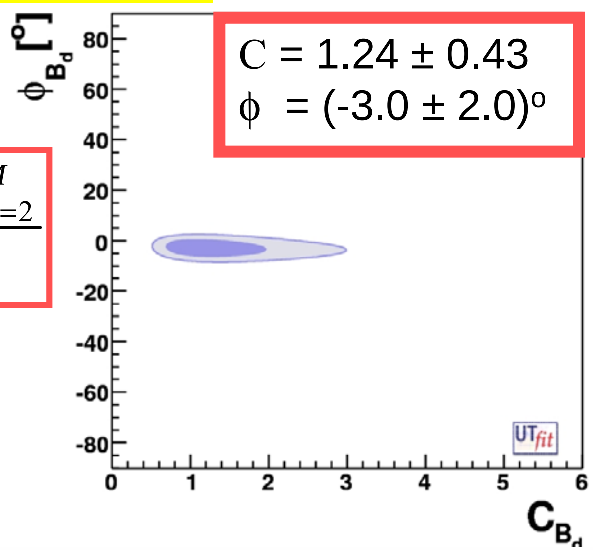
		ρ , η	C_d	φ_d	C_s	φ_s	$C_{\varepsilon K}$
Tree processes	γ (DK)	X					
Tree processes	V_{ub}/V_{cb}	X					
1↔3 family	Δm_d	X	X				
1↔3 family	ACP (J/Ψ K)	X		X			
1↔3 family	ASL		X	X			
1↔3 family	α (ρρ,ρπ,ππ)	X		X			
1↔3 family	ACH		X	X	X	X	
2↔3 family	$\Delta\Gamma_s/\Gamma_s$				X	X	
2↔3 family	Δm_s				X		
1↔2 familiy	ε_K	X					X
	In future :						
	ACP (J/Ψ ϕ)	~X				X	
	ASL(Bs)				X	X	
	γ (D_sK)	X					

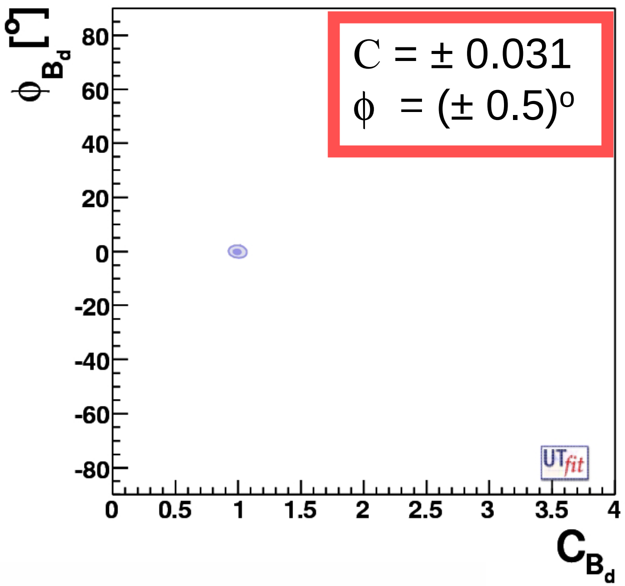
5 new free parameters
- C_s,φ_s — B_s mixing
- C_d,φ_d — B_d mixing
- $C_{\varepsilon K}$ — K mixing

Today :
fit possible with <u>10 contraints</u>
and <u>7 free parameters</u>
(ρ, η, C_d,φ_d ,C_s,φ_s, $C_{\varepsilon K}$)

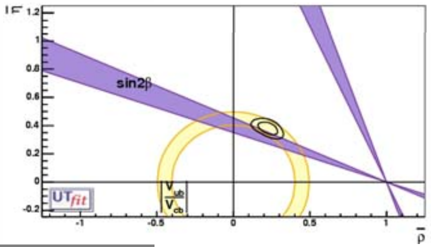
Model Indep. Analysis in ΔB=2

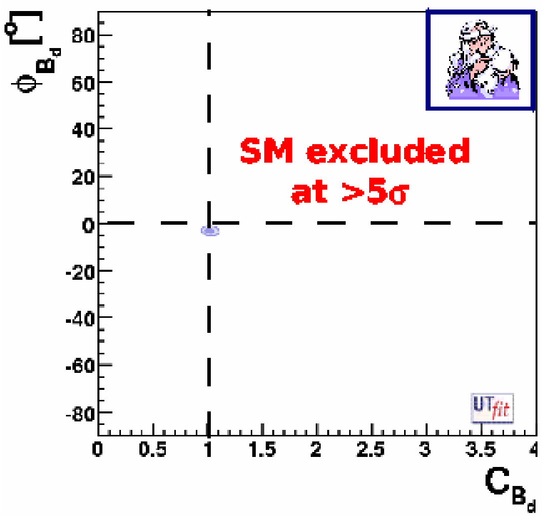
$$C_q e^{2i\varphi_d} = \frac{Q^{NP}_{\Delta B=2} + Q^{SM}_{\Delta B=2}}{Q^{SM}_{\Delta B=2}}$$



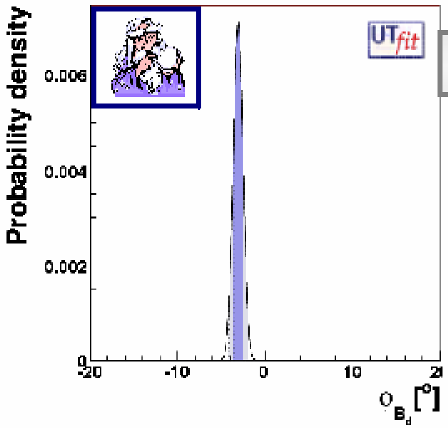


Assuming superB 2015 precision and the current V_{ub} vs sin2β "discrepancy" to be confirmed

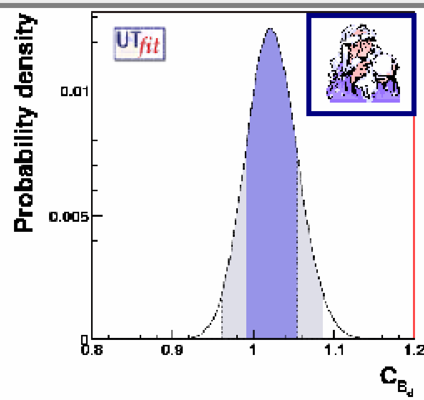




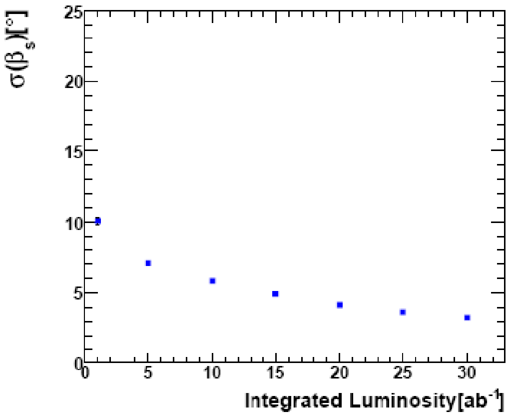
φ_{Bd} = (-3.09 ± 0.56)°

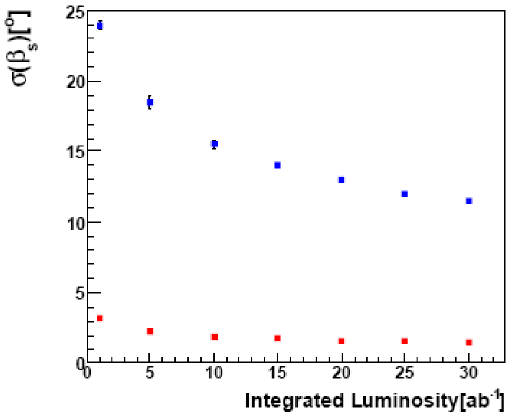


C_{Bd} = 1.023 ± 0.032

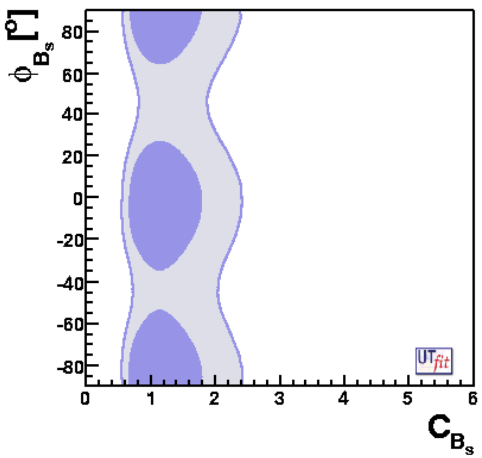


Bit more on B_s

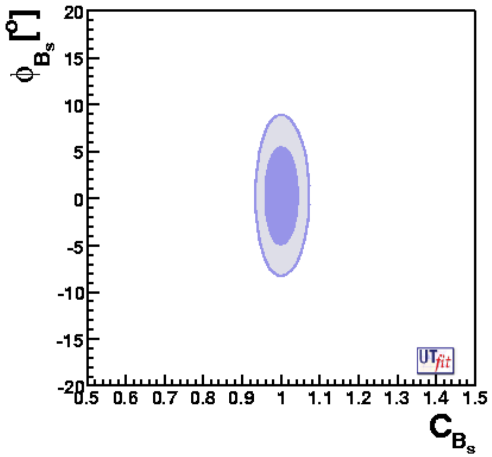




Today

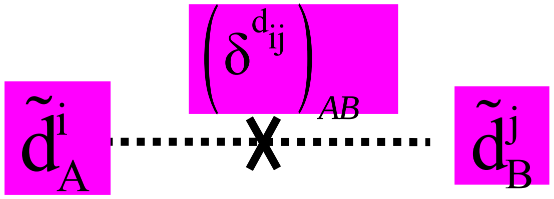


at Superb



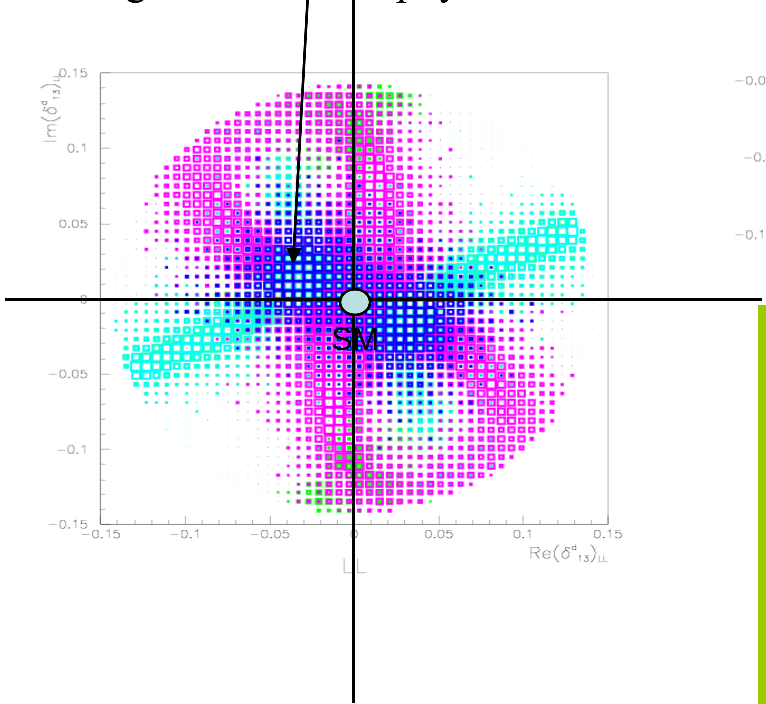
C(Bs) ~ 0.026

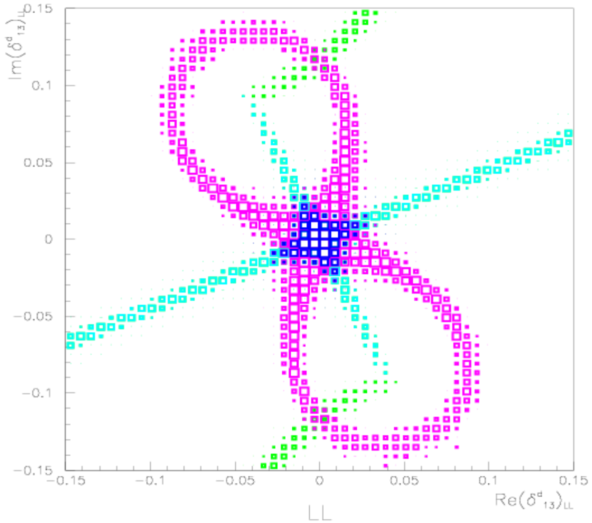
φ(Bs) ~ 1.9°



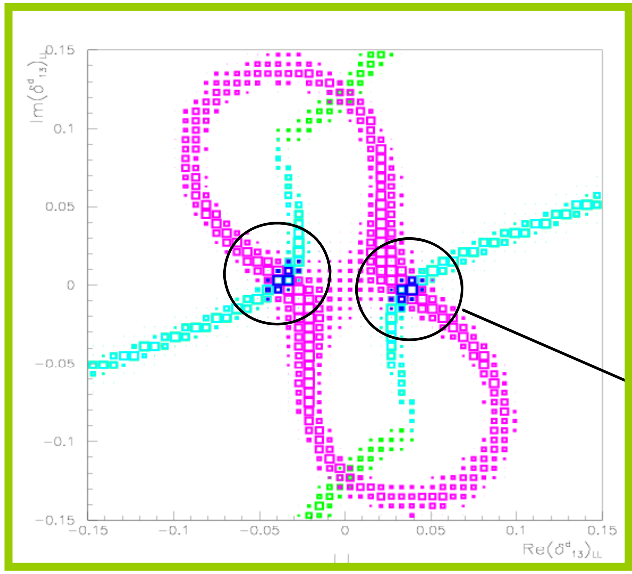
NP scale at 350 GeV

Due to the actual disagreement between V_{ub} and sin2b we see a slight hint of new physics





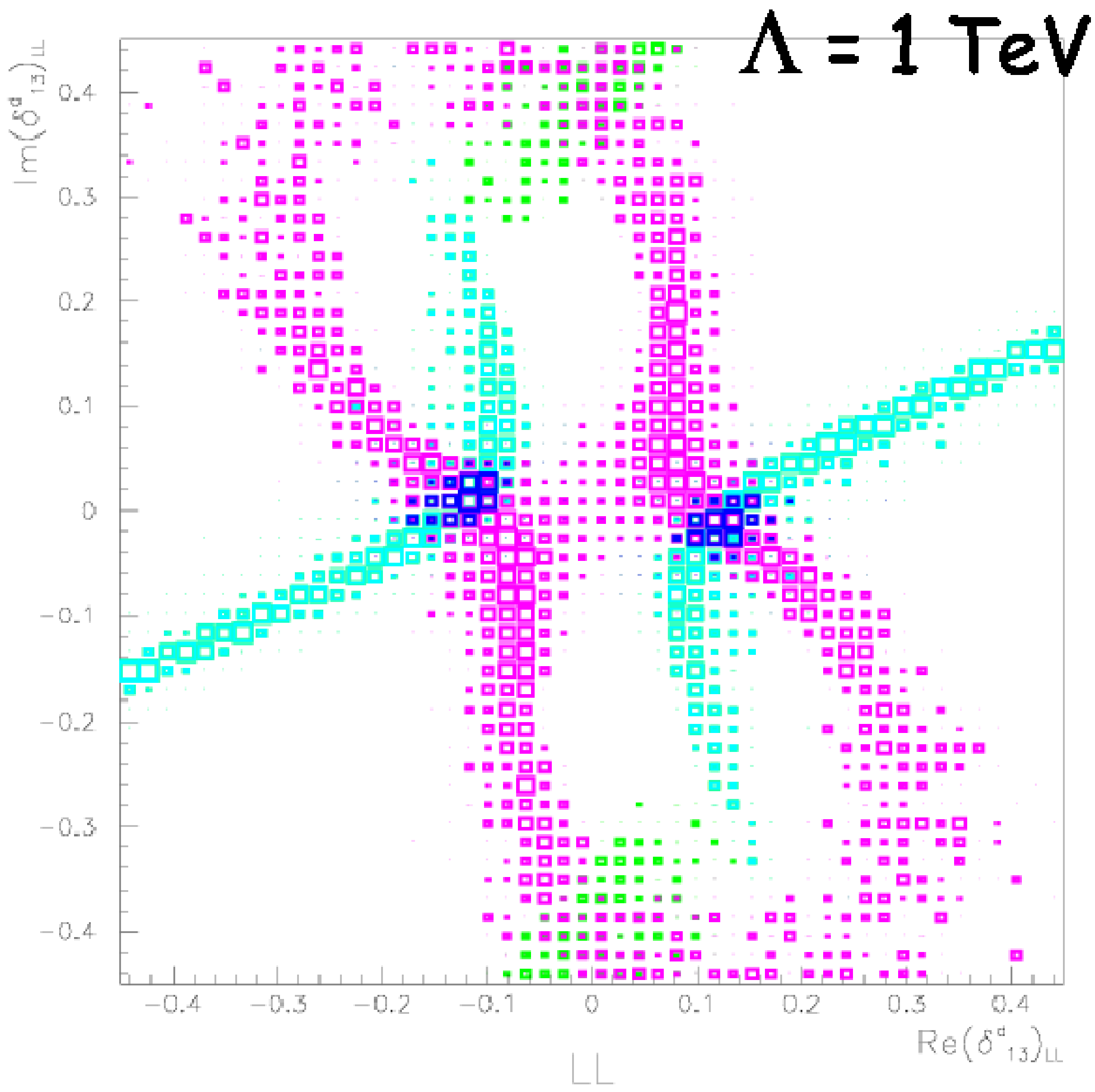
Re $(\delta^d_{13})_{LL}$ vs Im $(\delta^d_{13})_{LL}$
superB if disagreement disapper.



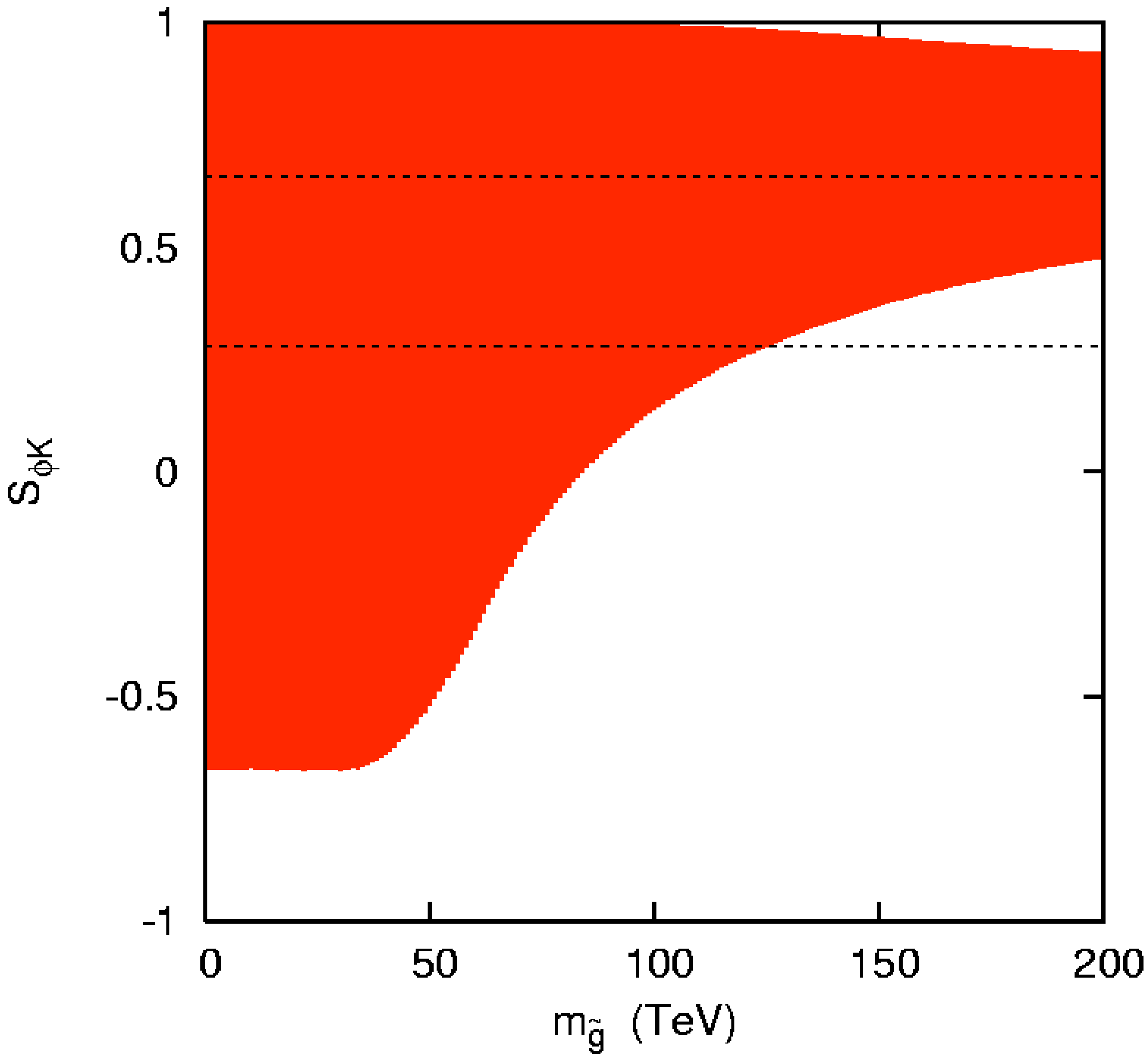
Re $(\delta^d_{13})_{LL}$ vs Im $(\delta^d_{13})_{LL}$
with
present disagreement

NP at
high significance !

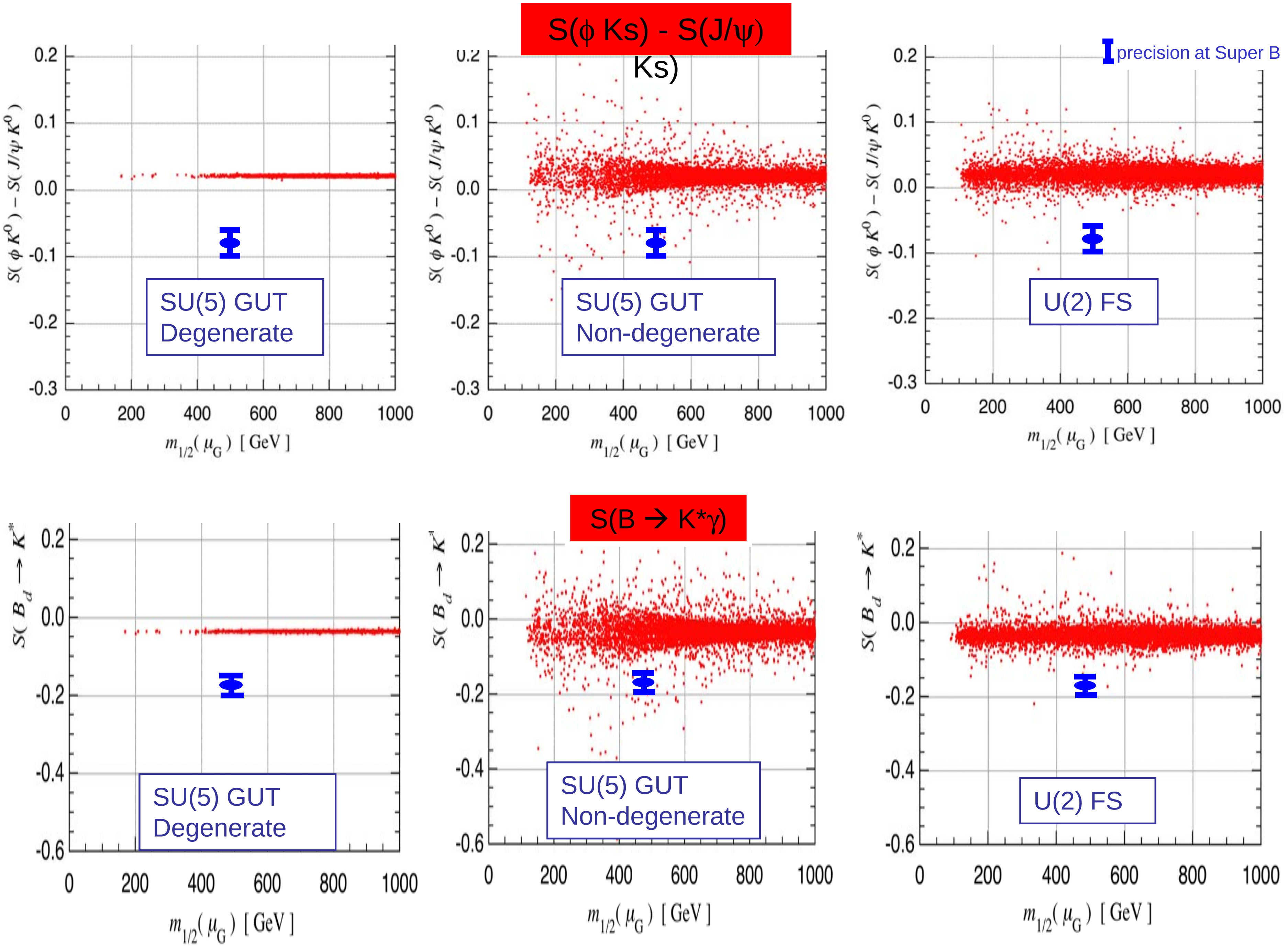
Constraint from Δm_d
Constraint from sin2β
Constraint from sin2β cos2β
All constraints


Λ = 1 TeV
Im(δ^d_13)_LL
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.4
−0.3
−0.2
−0.1
0
0.1
0.2
0.3
0.4
Re(δ^d_13)_LL
LL

Some process allow to explore
even higher NP region : example $S(\phi K_s)$



(Caution: This fig. does not take into account SUSY breakdown at large mass. Used for illustration purpose only


S(φ Ks) - S(J/ψ) Ks)
precision at Super B
SU(5) GUT Degenerate
SU(5) GUT Non-degenerate
U(2) FS
S(φ K0) − S(J/ψ K0)
m1/2(μG) [GeV]
S(B → K*γ)
S(Bd → K*
SU(5) GUT Degenerate
SU(5) GUT Non-degenerate
U(2) FS
m1/2(μG) [GeV]