Goals and organisation of the Warwick workshop

Workshop on New Physics with SuperB

14th-17th April 2009

Achille Stocchi
LAL -Universite Paris Sud/IN2P3

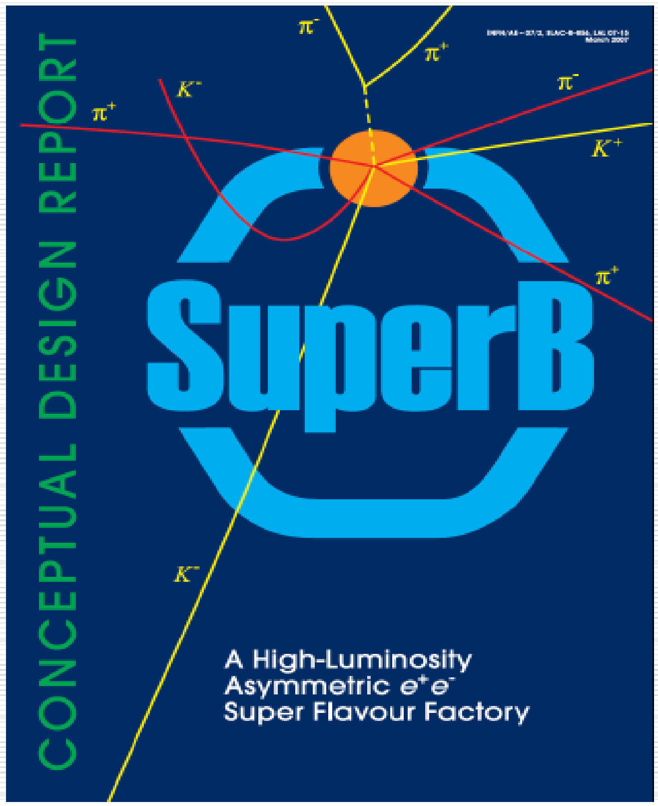
The TDR phase of the SuperB project will aim to a comprehensive document (TDR) in the time scale of 2 years from now.

The ‘deliverable’ of this activity on Physics will be the Physics section of SuperB TDR,

Intermediate step

A document is needed by the end of 2009 containing the motivation for SuperB (to get the project approved).
Needed/Asked also for European Strategy Group

A section of this “end-2009” document will be on physics



3 Chapters : Physics Case

On about 100 pages

Detector

Machine

Collective work on the Physics Case of SuperB was recently collected in these two documents

Special specific meeting

<u>to answer the IRC questions on physics and sharpen the physics case</u>

Proceedings
of
Super*B* Workshop VI

New Physics
at the
Super Flavor Factory

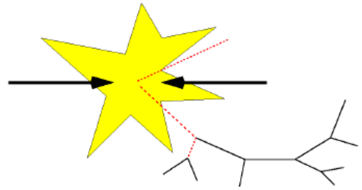
49 signers
~24 institutions

Valencia, Spain
January 7-15, 2008

Abstract

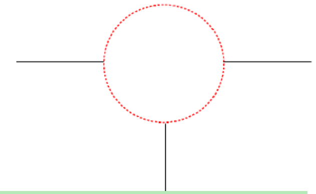
The sixth Super*B* Workshop was convened in response to questions posed by the INFN Review Committee that is evaluating the Super*B* project at the request of INFN. The various working groups addressed the capability of a high-luminosity flavor factory that can gather a data sample of 50 to 75 ab^{-1} in five years to elucidate New Physics phenomena unearthed at the LHC.

Exploration of two frontiers



“Relativistic path”

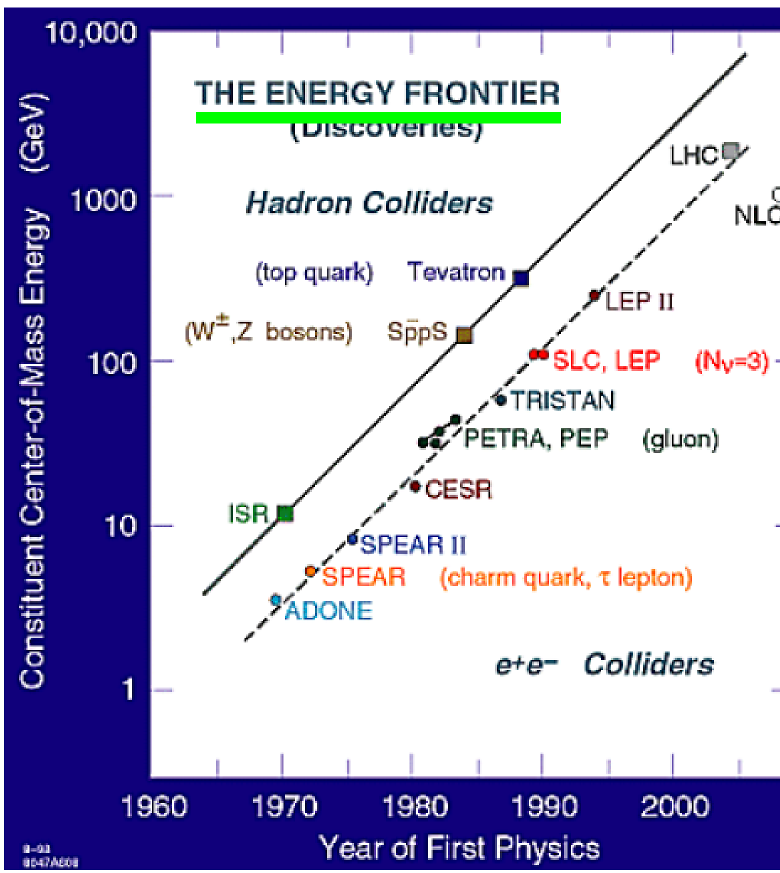
Crucial : Center-of-mass energy

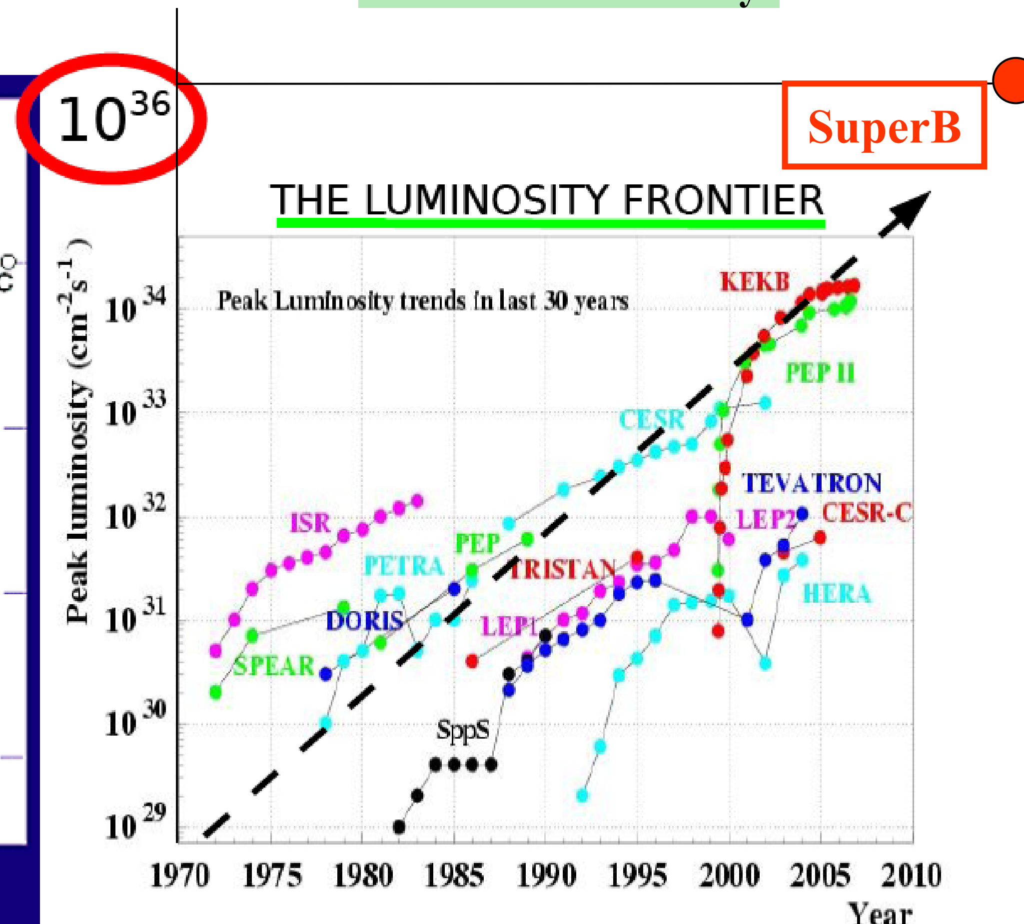


“Quantum path”

Crucial : Luminosity

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





Just few general principle to defend the fact that we should go on following the two ways :

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

We can just summarised that saying :

→ It is « natural » follow the quantum way

→ The NP is as usual under the corner…

We know that it is now enough to get SuperB approuved !

If we want to program a new machine today we have to demonstrate that we can perform flavour measurements such that :

- if NP particles are discovered at LHC we able study the flavour structure of the NP
- we can explore NP scale beyond the LHC reach

For this first point in other words..

1034 luminosity to have measurable effects <u>(anyhow)</u>
if NP particle with masses at the <u>EW scale</u>

1036 luminosity to have measurable effects <u>(anyhow)</u>
if NP particle with masses at the <u>TeV scale</u>

Few questions we should always keep in mind

Why the choice of a Super Flavour Factory, asymmetric ?

Is a Super Flavor Factory (SFF) a discovery machine in LHC era ?

Why $>10^{36}$ luminosity needed ?

Is SFF complementary to LHC ?

Would not be LHCb enough to perform flavour studies ?

My view of the SuperB Physics Program

put with where we think work is needed

(goals of this workshop and

of effort on Physics for TDR)

B physics @ U(4S)

As in CDR, some updated on Valencia

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
α $(B \to \pi\pi)$	$\sim 16°$	3°
α $(B \to \rho\rho)$	$\sim 7°$	1–2° (∗)
α $(B \to \rho\pi)$	$\sim 12°$	2°
α (combined)	$\sim 6°$	1–2° (∗)
γ $(B \to DK$, $D \to CP$ eigenstates)	$\sim 15°$	2.5°
γ $(B \to DK$, $D \to$ suppressed states)	$\sim 12°$	2.0°
γ $(B \to DK$, $D \to$ multibody states)	$\sim 9°$	1.5°
γ $(B \to DK$, combined)	$\sim 6°$	1–2°
$2\beta + \gamma$ $(D^{(*)\pm}\pi^\mp,\ D^\pm K^0_S\pi^\mp)$	20°	5°
$S(\phi K^0)$	0.13	0.02 (∗)
$S(\eta' K^0)$	0.05	0.01 (∗)
$S(K^0_S K^0_S K^0_S)$	0.15	0.02 (∗)
$S(K^0_S \pi^0)$	0.15	0.02 (∗)
$S(\omega K^0_S)$	0.17	0.03 (∗)
$S(f_0 K^0_S)$	0.12	0.02 (∗)
$\lvert V_{cb}\rvert$ (exclusive)	4% (∗)	1.0% (∗)
$\lvert V_{cb}\rvert$ (inclusive)	1% (∗)	0.5% (∗)
$\lvert V_{ub}\rvert$ (exclusive)	8% (∗)	3.0% (∗)
$\lvert V_{ub}\rvert$ (inclusive)	8% (∗)	2.0% (∗)

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 (†)
$S(K^0_S\pi^0\gamma)$	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

Possible also at LHCb

Similar precision at LHCb

τ physics

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}
$\mathcal{B}(\tau \to \ell K_s^0)$	2×10^{-10}

Charm at U(4S) and threshold

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}
$D^0 \to K_S^0\pi^+\pi^-$	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}
$D^0 \to K^+\pi^-$	x'^2	To be evaluated at LHCb	3×10^{-5}
	y'		7×10^{-4}
$D^0 \to K^+K^-$	y_{CP}		5×10^{-4}
$D^0 \to K_S^0\pi^+\pi^-$	x		4.9×10^{-4}
	y		3.5×10^{-4}
	$\|q/p\|$		3×10^{-2}
	ϕ		$2°$

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}

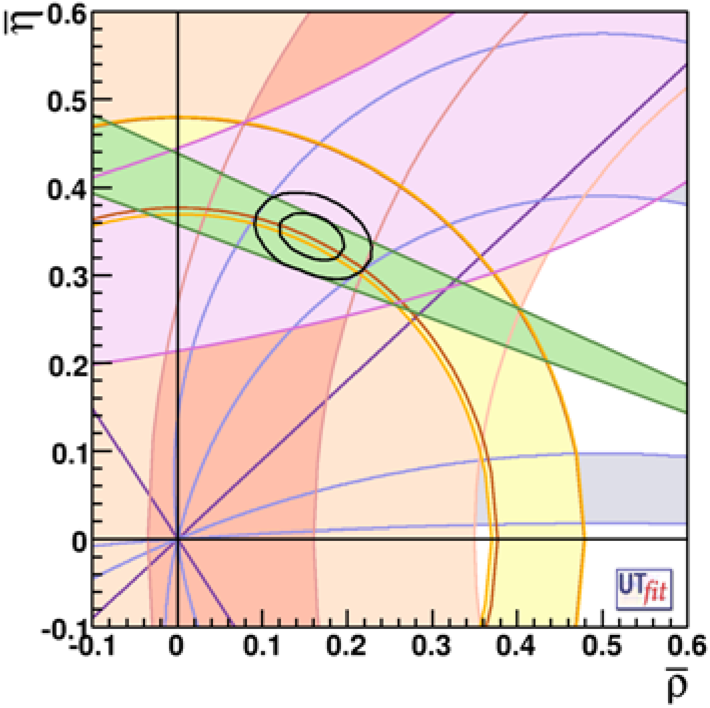
B_s at U(5S)

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_{SL}^s	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°

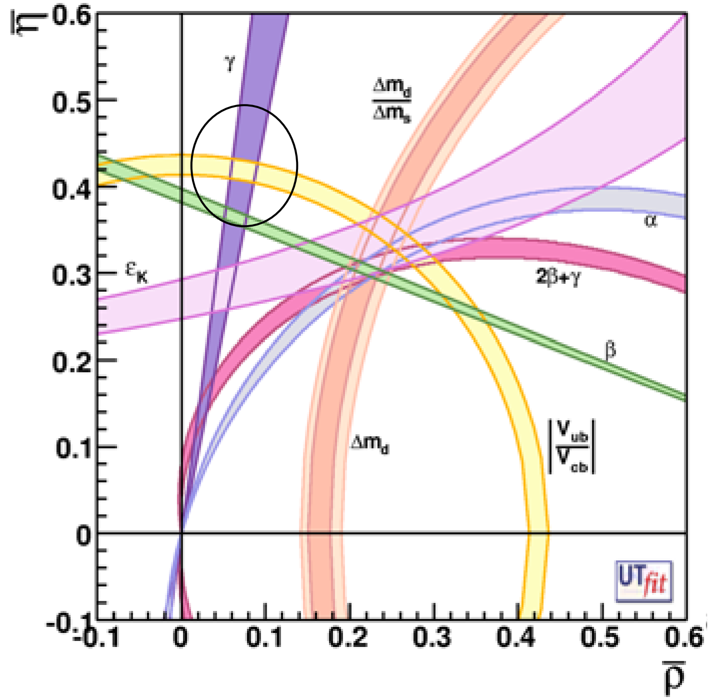
B_s : not discussed today. Maybe to be Revisited for next Workshops

In SM (or metrology)

Today



SuperB+Lattice improvements

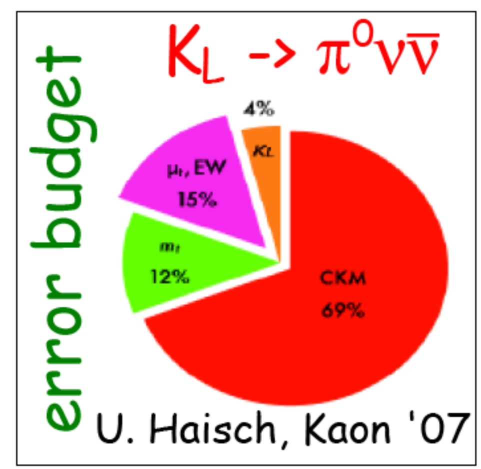


$\rho = 0.163 \pm 0.028$
$\eta = 0.344 \pm 0.016$

↓

$\rho = \pm 0.0028$
$\eta = \pm 0.0024$

Improving CKM is crucial to look for NP



Crucial among others :

V_{ub} unique SuperB
(importance of Lattice and theory in general)

γ @ ~1 degree. Factor ~3 better than LHCb.
Important (?). Could we go at a fraction of a degree ?

GOLDEN MODES in B Sector

	H^+ high $\tan\beta$	Minimal FV	Non-Minimal FV (1-3)	Non-Minimal FV (2-3)	NP Z-penguins	Right-Handed currents
$\mathcal{B}(B \to X_s \gamma)$		X		O		O
$A_{CP}(B \to X_s \gamma)$				X		O
$\mathcal{B}(B \to \tau \nu)$	X-CKM					
$\mathcal{B}(B \to X_s l^+ l^-)$				O	O	O
$\mathcal{B}(B \to K \nu \overline{\nu})$				O	X	
$S(K_S \pi^0 \gamma)$						X
β			X-CKM			X

....

....

X The GOLDEN channel for the given scenario

○ Not the GOLDEN channel for the given scenario but can show experimentally measurable deviations from SM.

Where –CKM means that Lattice improvement are crucial

These are also the channels are also used to « define » the final geometry of the detector

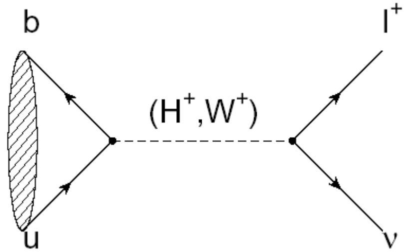
(Synergy with DGWG)

For mini-TDR these channels has to be reconsidered with attention performing

- sensitivity studies
- impact on the given NP scenario

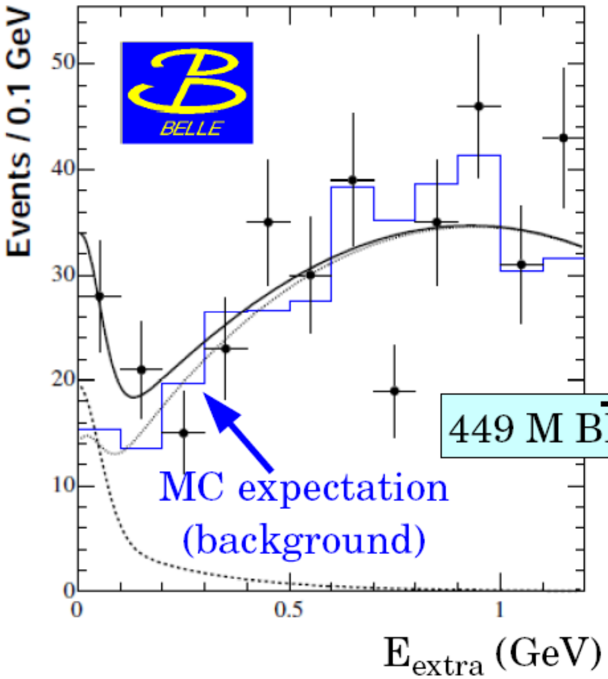
We should extent this table (if needed) for new B observable, τ and charm and for the physics models

leptonic decay B→lν



Milestone :

First leptonic decay seen on B meson

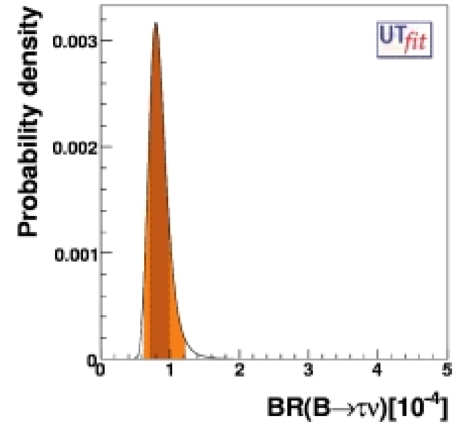


Exp. likelihood BABAR+BELLE

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%	(3-4)% (†)
$\mathcal{B}(B \to \mu\nu)$	visible	(5-6)%
$\mathcal{B}(B \to D\tau\nu)$	10%	2% Interesting ?

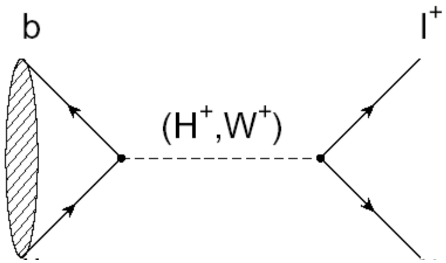
(+) systematically limited (to be studied with the improved detector)

Br(B→τν) up to 3-4% (below limited by systematics) ..probably not with improved detector.

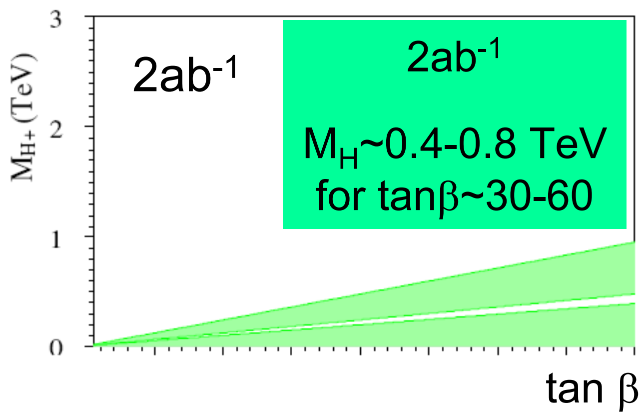
Br(B→μν) can be measured with the some precision not limited by syst. But…

The background from B→μν(γ) should be addressed *(see E. Kou, D. Beciveric work)*

Higgs-mediated NP in MFV at large tanβ

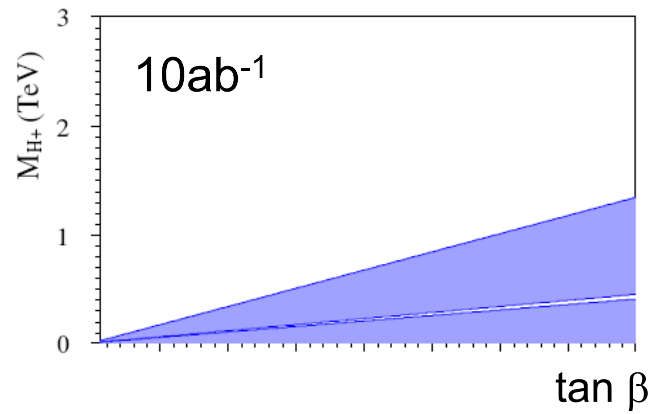


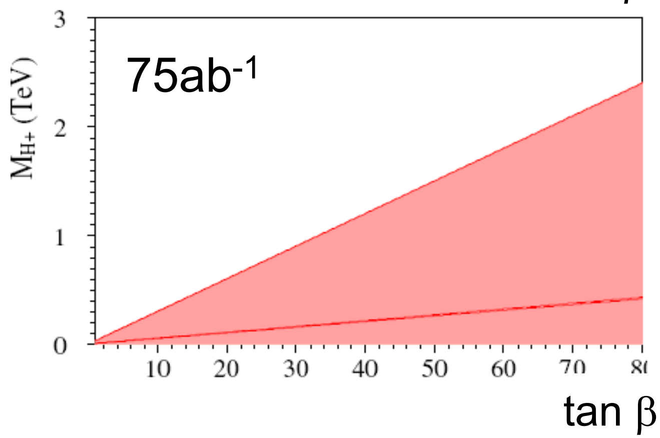
$$BR(B\to\tau\nu) = BR_{SM}(B\to\tau\nu)\left(1 - \frac{m_B^2}{M_H^2}\tan^2\beta\right)^2$$



$2ab^{-1}$

M_H~0.4-0.8 TeV for tanβ~30-60





SuperB -$75ab^{-1}$

M_H~1.2-2.5 TeV for tanβ~30-60

Importance of having very large sample >$75ab^{-1}$

Lattice improvements are crucial here on $f_B \sqrt{B_B}$

SuperB precisions ⟷ SuperLattice precisions

Work could re-start on that..

Table A-2. *Prediction of the accuracy that can be reached in lattice QCD determinations of various hadronic parameters assuming the availability of a computational power of about 6 TFlops (4th column), 60 TFlops (5th column) and 1-10 PFlops (6th column). The predictions given for the 6 TFlops and 60 TFlops cases have been presented by S. Sharpe in [5]. The accuracy reached at present in the determination of the various parameters is also shown (3rd column).*

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 %

We are already there..

Work done by Vittorio Lubicz for the CDR

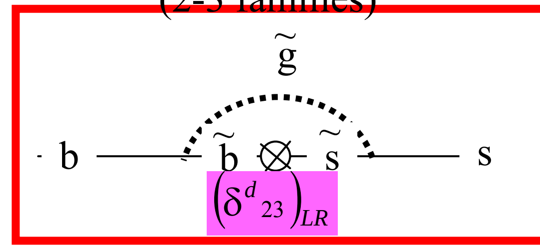
MSSM+generic soft SUSY breaking terms

Flavour-changing NP effects in the squark propagator

→ NP scale SUSY mass $\tilde{m} \sim m_{\tilde{g}}$

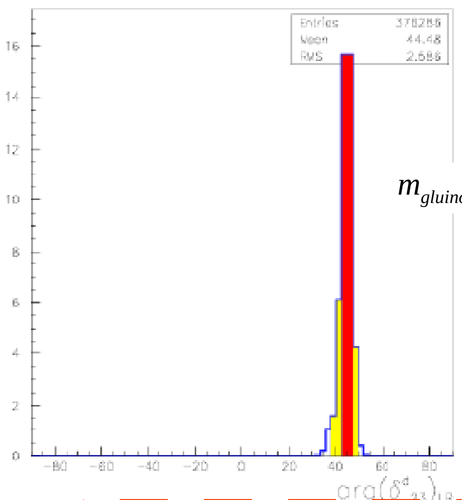
→ flavour-violating coupling $(\delta^q_{ij})_{AB} \equiv \frac{(M^2_{ij})^q_{AB}}{\tilde{m}^2}$

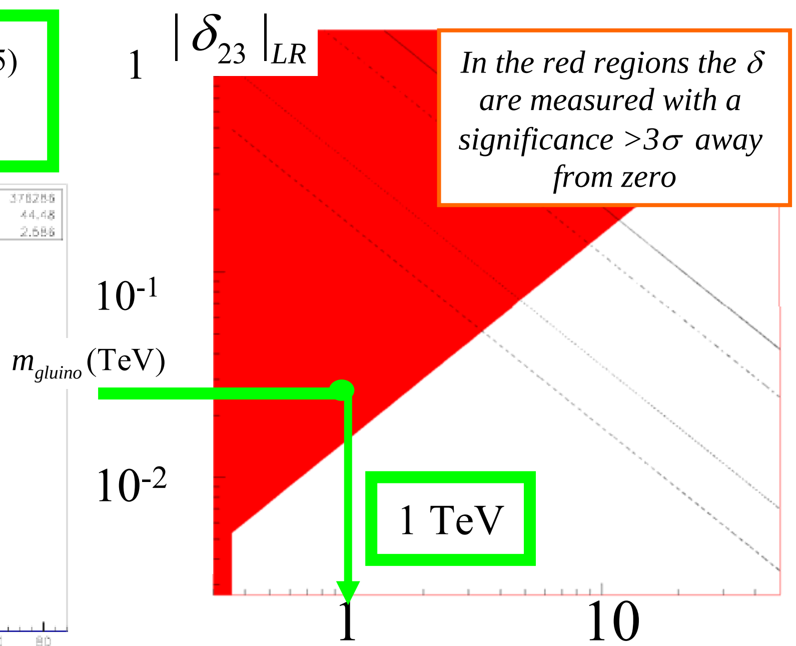
New Physics contribution (2-3 families)



$|\delta_{23}|_{LR} = (0.026 \pm 0.005)$

$\text{Arg}(\delta_{23})_{LR} = (44.5 \pm 2.6)^o$





sensitive to $m_{\tilde{q}}$ < 20 TeV

sensitive to $|(\delta^d_{23})_{LR}| > 10^{-2}$

for $m_{\tilde{q}}$ < 1 TeV

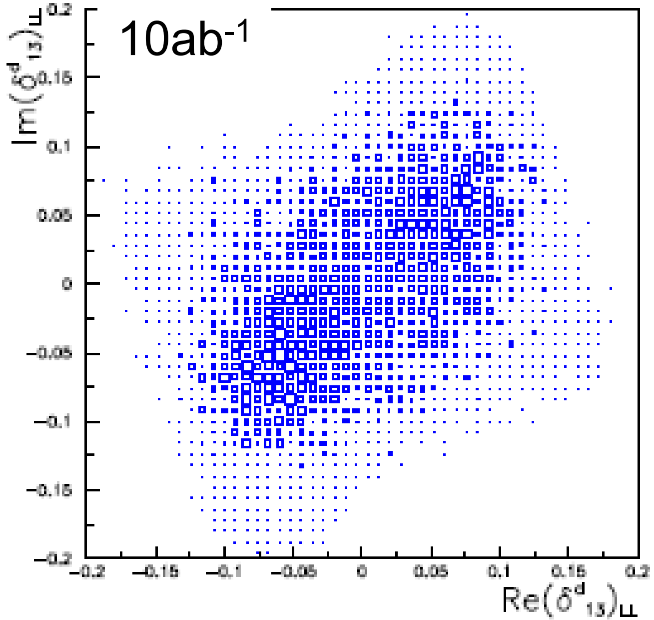
Theortical issues on radiative decays

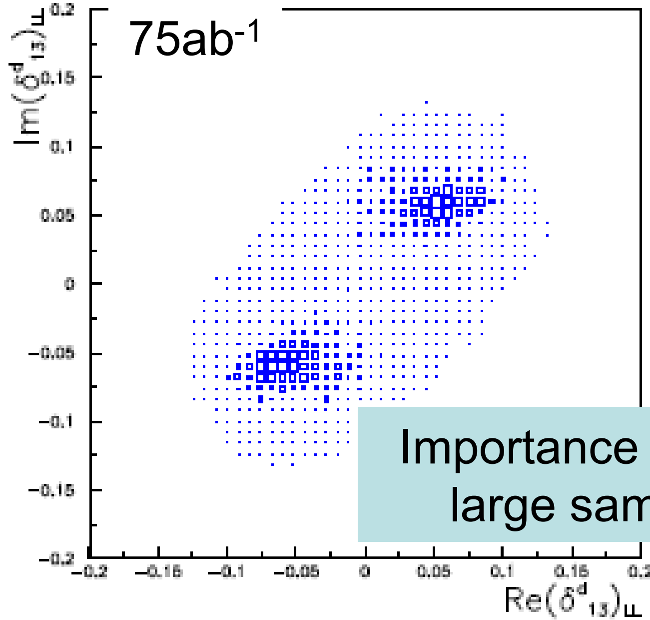
Main actors :

Mode	Sensitivity		
	Current	Expected ($10\ ab^{-1}$)	Expected ($75\ ab^{-1}$)
$\mathcal{B}(B \to X_s\gamma)$	7%	5%	3%
$A_{CP}(B \to X_s\gamma)$	0.037	0.01	0.004–0.005
$\mathcal{B}(B \to X_s l^+ l^-)$	23%	15%	4–6%
$A_{FB}(B \to X_s l^+ l^-)_{s_0}$	not measured	30%	4–6%

Not used here

Determination of Susy mass insertion parameter $(\delta_{13})_{LL}$ with 10 ab^{-1} and 75 ab^{-1}





Importance of having very large sample >75ab^{-1}

constraints: β, A_{SL}, Δm_d

β still the leader in this sector

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

A_{SL} revisited, never done in details

Lattice improvements are quite crucial

Two directions we should be developed
as indicated by Marco Ciuchini in his plenary at Orsay

1

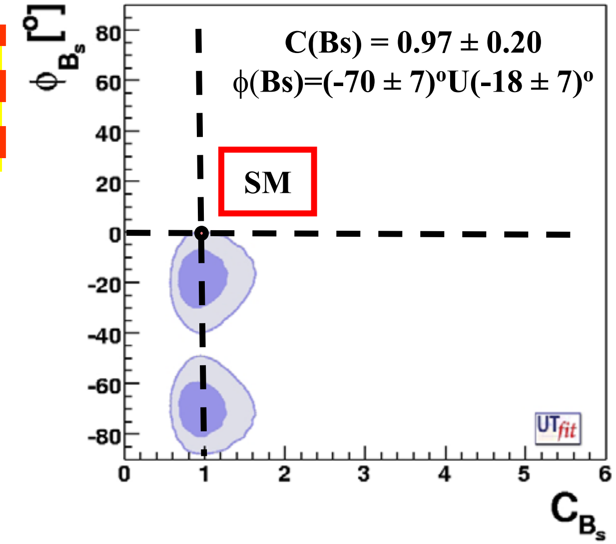
Assume that the LHC measured:

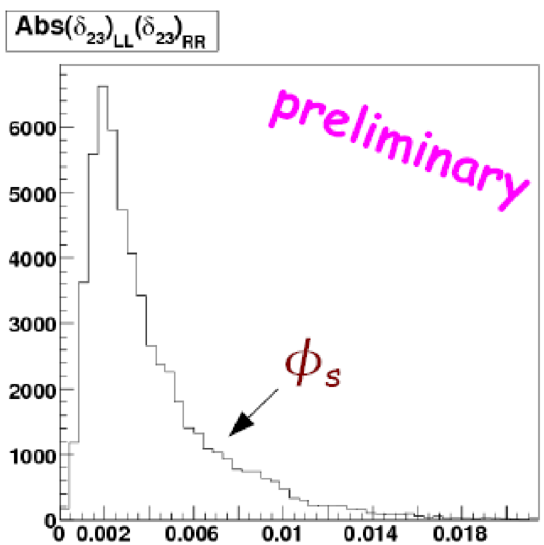
$m_{\tilde{q}} \sim 500$ GeV

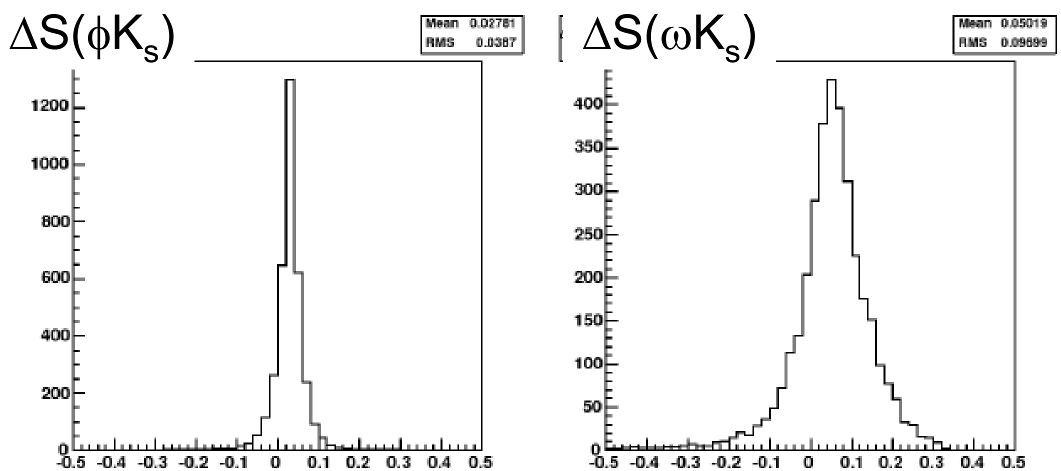
$\Phi_s \sim 10\ \Phi_s^{SM} \sim -20°$

This would already imply:

$|(\delta^d_{23})_{LL}(\delta^d_{23})_{RR}| \sim 0.003$

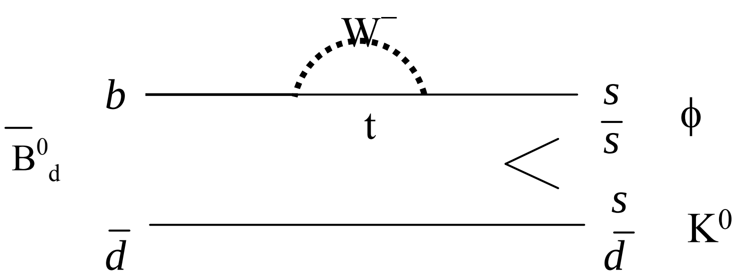


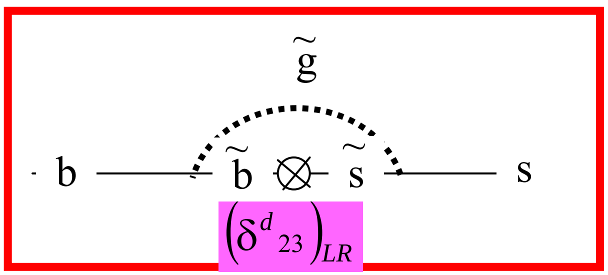


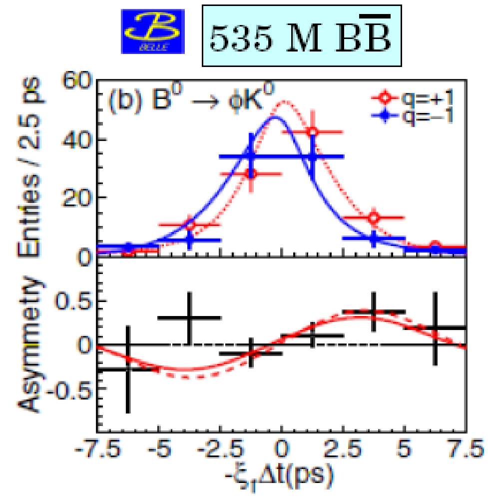


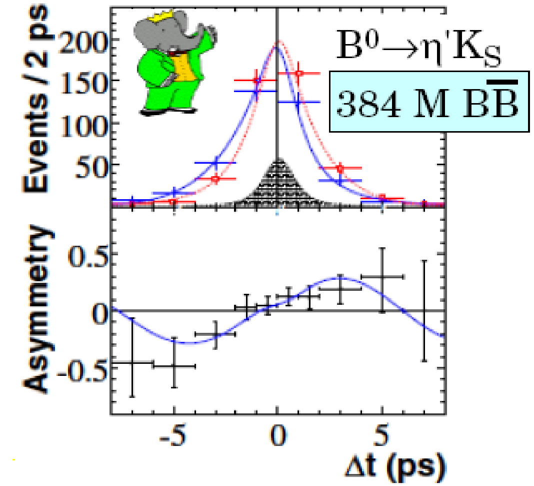
ΔS up to 0.1 in b→ s penguins-dominated
CP asymmetry

Precisions for these modes in the CDR





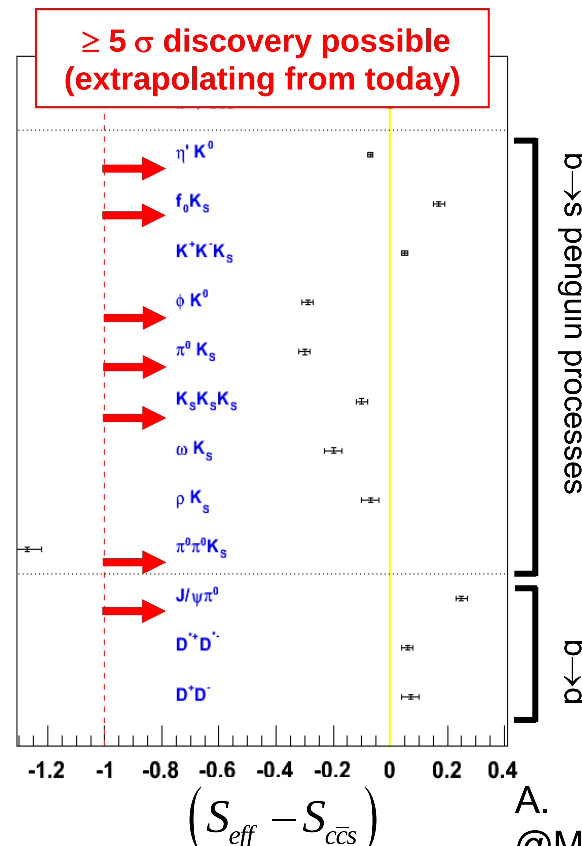




Many channels can be measured with ΔS~(0.01-0.04)

Observable	B Factories (2 ab^{-1})	SuperB
$S(\phi K^0)$	0.13	0.02 (*)
$S(\eta' K^0)$	0.05	0.01 (*)
$S(K^0_S K^0_S K^0_S)$	0.15	0.02 (*)
$S(K^0_S \pi^0)$	0.15	0.02 (*)
$S(\omega K^0_S)$	0.17	0.03 (*)
$S(f_0 K^0_S)$	0.12	0.02 (*)

(*) theoretical limited



A. Bevan @Moriond

2

An example: hierarchical soft terms

Nardecchia, Giudice, Romanino, arXiv:0812.3610
Cohen, Kaplan, Nelson, hep-ph/9607394
Dine, Kagan, Samuel, PLB243 (1990)

Sparticles at the EW scale

but for 1st and 2nd generation squarks and sleptons

- no "unnatural" correction to the Higgs mass
- alleviate the flavour problem
- indicate "natural" values for the δ's:

$$\hat{\delta}^{LL}_{db} \approx V^*_{td} \sim \mathbf{0.01} \qquad \hat{\delta}^{LL}_{sb} \approx V^*_{ts} \sim \mathbf{0.05}$$

$$\hat{\delta}^{LR}_{i3} \equiv \frac{\mathcal{M}^2_{L3,R3}}{\tilde{m}^2} \hat{\delta}^{LL}_{i3} \qquad i,j = 1,2$$

$$\hat{\delta}^{LL}_{ij} \equiv \hat{\delta}^{LL}_{i3} \hat{\delta}^{LL*}_{j3} \qquad \hat{\delta}^{LR}_{ij} \equiv \frac{\mathcal{M}^2_{L3,R3}}{\tilde{m}^2} \hat{\delta}^{LL}_{i3} \hat{\delta}^{RR*}_{j3}$$

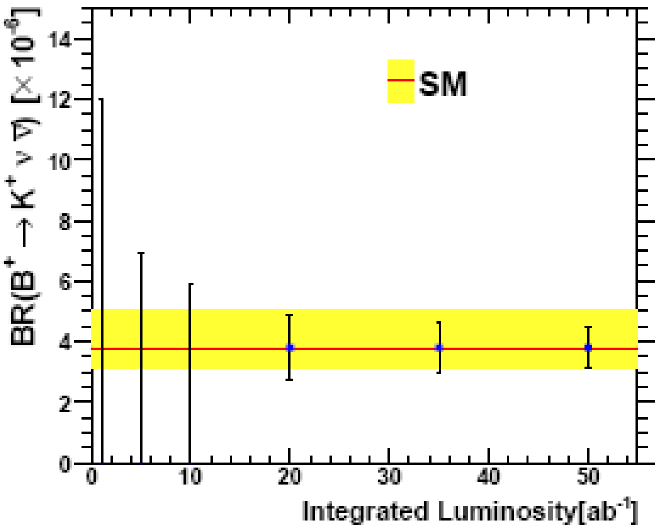
these figures are in the ballpark of SuperB sensitivities

Branching fraction Br(B → $K^{(*)}$ ν ν)

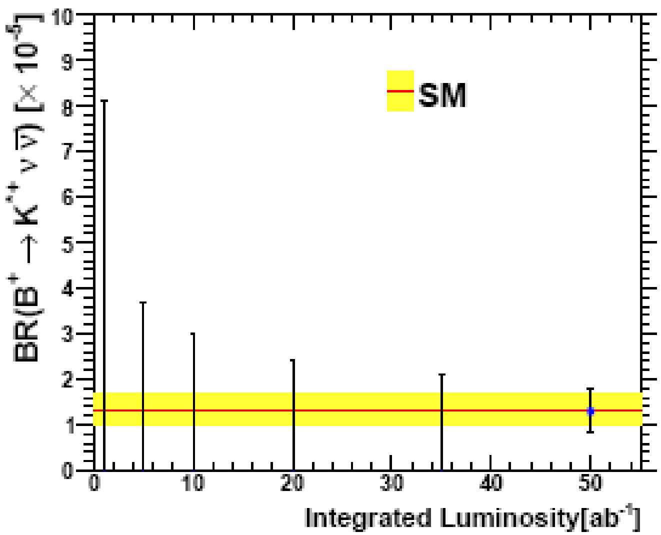
Today

The best UL < 14 10^{-6}

SM BF= 4 10^{-6}



$$B^+ \to K^+ \nu \bar{\nu}$$



$$B^+ \to K^{*+} \nu \bar{\nu}, (K^+ \to K_s \pi^+)$$

~20ab^{-1} are needed for observation
>50ab^{-1} for precise measurement

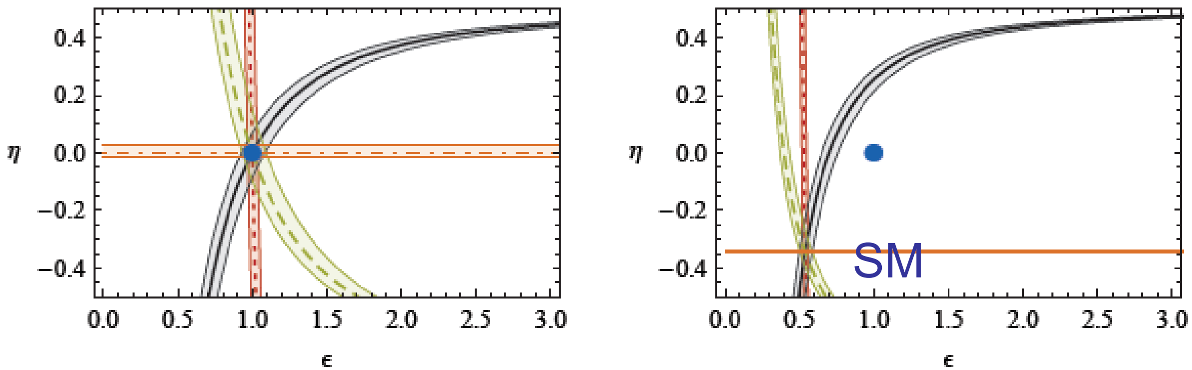
As a matter as example.

Our work triggered new studies. This new study trigger us again….

New strategies for New Physics search in $B \to K^*\nu\bar{\nu}$, $B \to K\nu\bar{\nu}$ and $B \to X_s\nu\bar{\nu}$ decays

arXiv:0902.0160v1 [hep-ph] 1 Feb 2009

Wolfgang Altmannshofer[a], Andrzej J. Buras[ab], David M. Straub[a] and Michael Wick[a]



$$\mathrm{BR}(B \to K^*\nu\bar{\nu}) = 6.8 \times 10^{-6}\,(1 + 1.31\,\eta)\epsilon^2\,,$$ green

$$\mathrm{BR}(B \to K\nu\bar{\nu}) = 4.5 \times 10^{-6}\,(1 - 2\,\eta)\epsilon^2\,,$$ blue

$$\mathrm{BR}(B \to X_s\nu\bar{\nu}) = 2.7 \times 10^{-5}\,(1 + 0.09\,\eta)\epsilon^2\,,$$ Red dotted

$$\longrightarrow \langle F_L \rangle = 0.54\,\frac{(1 + 2\,\eta)}{(1 + 1.31\,\eta)}\,.$$ Red dotted-dashed

The analysis of four observable can give large deviations from SM

QUITE SENSITIVE TO
Non-MFV interactions and new right-handed down quark couplings

We have to trigger more and more people work and to invite people to extrapolate their works with SuperB precisions (<u>maybe offering agreed table of SuperB measurements</u>

Two crucial questions :

The case of the « worst scenario case »
Worthwhile to shapren the arguments ?

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.

$\Delta F=2$

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

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

Today
Λ(MFV) > 2.3Λ_0 @95C.L.

NP masses >200GeV

SuperB
Λ(MFV) >~6-7Λ_0 @95C.L.

NP masses >700GeV

This range can be pushed up to ~1TeV including also $\Delta F=1$ processes ($b \rightarrow s\gamma$).

MFV : SNOWMASS points

SPS	$M_{1/2}$ (GeV)	M_0 (GeV)	A_0 (GeV)	$\tan\beta$	μ
1 a	250	100	-100	10	> 0
1 b	400	200	0	30	> 0
2	300	1450	0	10	> 0
3	400	90	0	10	> 0
4	300	400	0	50	> 0
5	300	150	-1000	5	> 0

	SPS1a	SPS4	SPS5
$\mathcal{R}(B \to s\gamma)$	0.919 ± 0.038	0.248	0.848 ± 0.081
$\mathcal{R}(B \to \tau\nu)$	0.968 ± 0.007	0.436	0.997 ± 0.003
$\mathcal{R}(B \to X_s l^+ l^-)$	0.916 ± 0.004	0.917	0.995 ± 0.002
$\mathcal{R}(B \to K\nu\overline{\nu})$	0.967 ± 0.001	0.972	0.994 ± 0.001
$\mathcal{B}(B_d \to \mu^+\mu^-)/10^{-10}$	1.631 ± 0.038	16.9	1.979 ± 0.012
$\mathcal{R}(\Delta m_s)$	1.050 ± 0.001	1.029	1.029 ± 0.001
$\mathcal{B}(B_s \to \mu^+\mu^-)/10^{-9}$	2.824 ± 0.063	29.3	3.427 ± 0.018
$\mathcal{R}(K \to \pi^0\nu\overline{\nu})$	0.973 ± 0.001	0.977	0.994 ± 0.001

SPS4 ruled out by present values of B→sγ.

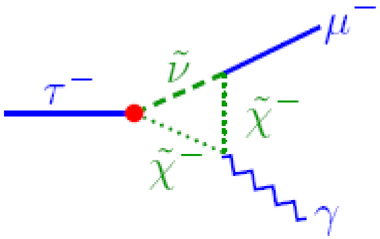
SPS1a is the least favorable for flavour, but SuperB and only SuperB can observe 2 σ deviations in several observables

Define some benchmark points. Adding flavour structure on «SnowMass » points.

First adding flavour structure to these working points

Lepton Flavour Violation $\tau \to \mu \gamma$. We can gain a very important order of magnitude $10^{-8} \to 10^{-9}$

Complementarity with $\mu \to e \gamma$

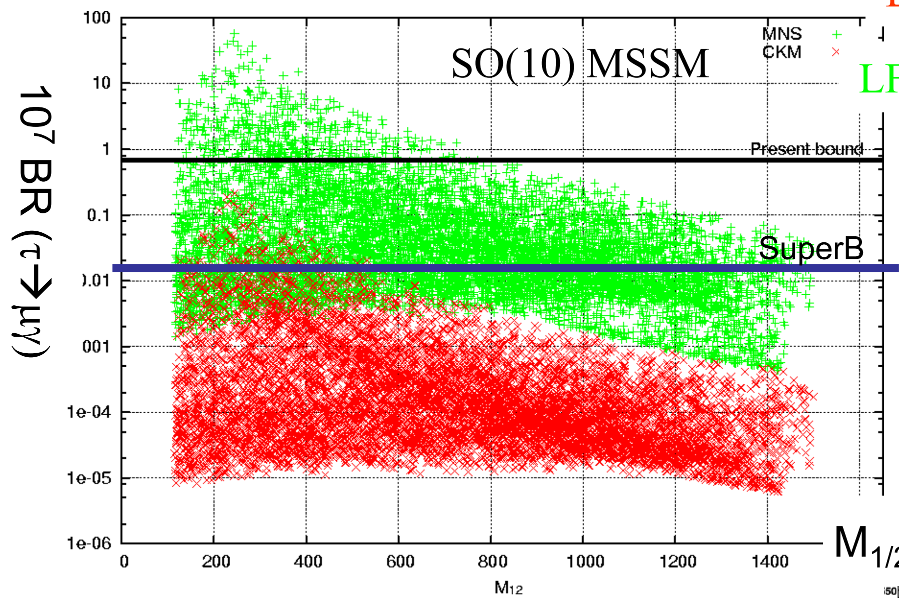


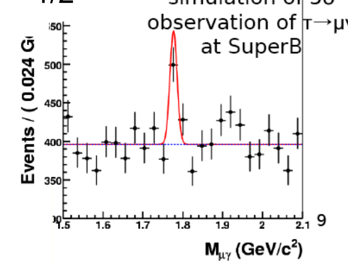
Process	Sensitivity
$\mathcal{B}(\tau \to \mu \gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to e \gamma)$	2×10^{-9}
$\mathcal{B}(\tau \to \mu \mu \mu)$	2×10^{-10}
$\mathcal{B}(\tau \to eee)$	2×10^{-10}
$\mathcal{B}(\tau \to \mu \eta)$	4×10^{-10}
$\mathcal{B}(\tau \to e \eta)$	6×10^{-10}
$\mathcal{B}(\tau \to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

MEG sensitivity $\mu \to e\gamma$ ~10^{-13}

LFV from CKM

LFV from PMNS





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

Letpon MFV GUT models

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

Discrimination between SUSY and LHT @ SuperB with τ

Blanke et al., hep-ph/0702136
SuperB CDR, arXiv:0709.0451

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

The ratio
$\tau \to lll$ / $\tau \to \mu\gamma$
is not suppressed in LHT by α_e as in MSSM

Precision to be revisited.
Impact from polarization

Polarized beam also provide novel additional handle on backgrounds

Establish the need of polarisation is an important issue

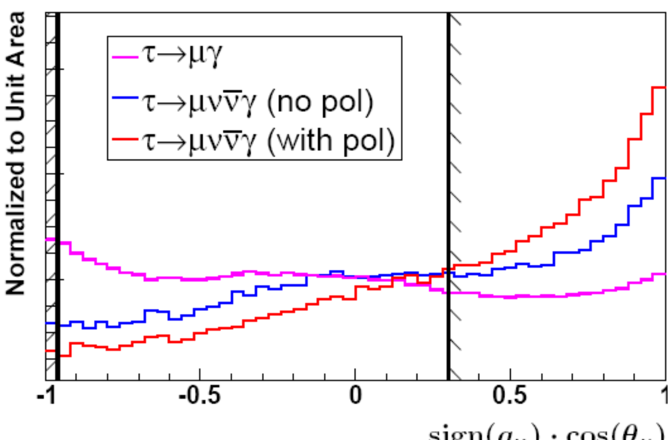


FIG. 15: Distribution of the cosine of the signal-side muon multiplied by the muon charge for signal and background events with and without electron beam polarization in the $\tau^\pm \to \mu^\pm\gamma$ search analysis at Super*B*.

MFV : Snowmass points on τ

SuperB with 75 ab^{-1}, evaluation assuming the most conservative scenario about syst. errors

SPS	$M_{1/2}$ (GeV)	M_0 (GeV)	A_0 (GeV)	$\tan\beta$	μ
1 a	250	100	-100	10	> 0
1 b	400	200	0	30	> 0
2	300	1450	0	10	> 0
3	400	90	0	10	> 0
4	300	400	0	50	> 0
5	300	150	-1000	5	> 0

LFV	Snowmass points predictions						SuperB	
	1 a	1 b	2	3	4	5	90% UL	**5σ disc**
$BF(\tau \to \mu\gamma) \times 10^{-9}$	4.2	7.9	0.18	0.26	97	0.019	**1÷2**	5
$BF(\tau \to 3\mu) \times 10^{-12}$	9.4	18	0.41	0.59	220	0.043	200	880

SuperKEKB worse by factor $\sqrt{5}$ for $BF(\tau \to \mu\gamma)$ and 5 for $BF(\tau \to \mu\mu\mu)$

This workshop should (re-)address the importance of other observable on τ and which is the importance of polarized beams.

Charm Physics

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

Charm physics at threshold **0.3 ab^{-1}**

Consider that running 2 month at threshold we will collect 500 times the stat. of CLEO-C

Strong 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°

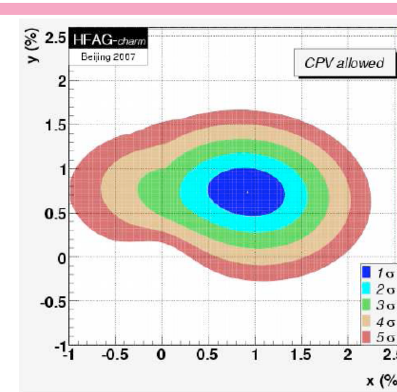
Rare decays FCNC down to 10^{-8}

@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

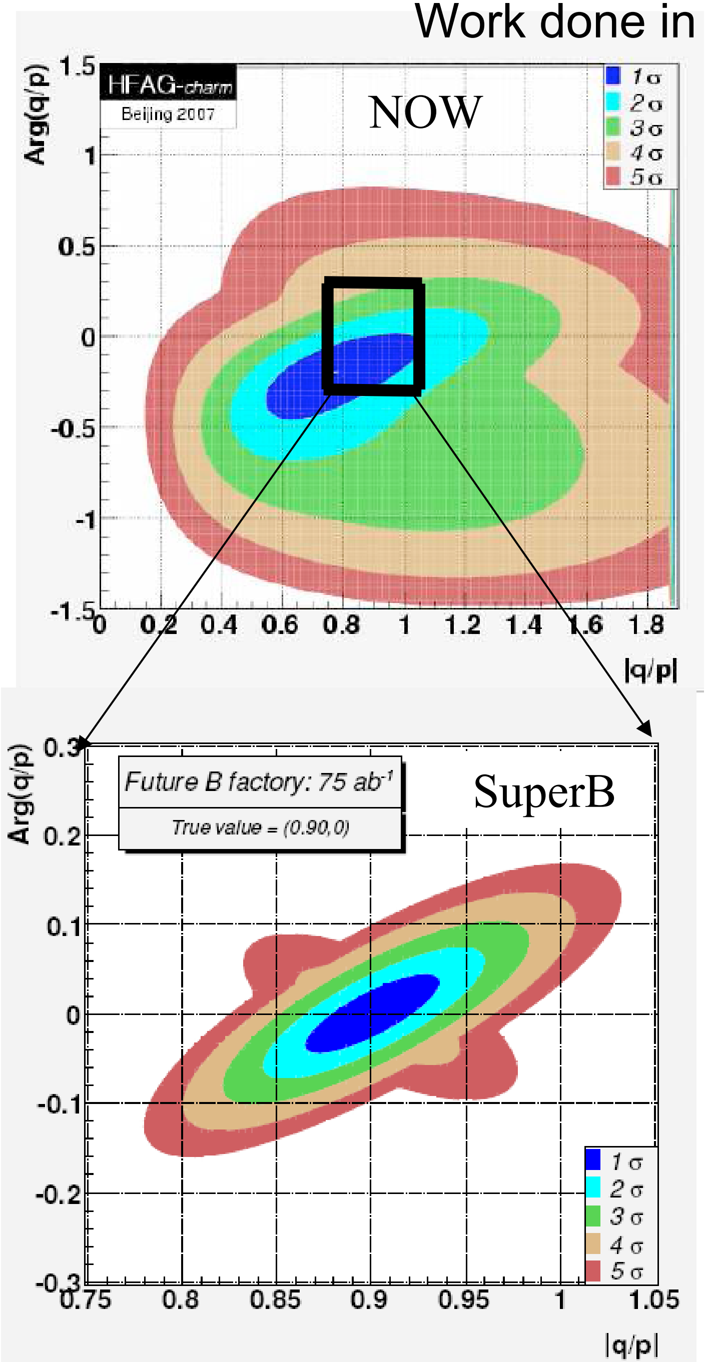
Better studied using the high statistics collected at $\Upsilon(4S)$



Mode	Observable	B Factories (2 ab^{-1})	Super$B$ (75 ab^{-1})
$D^0 \to K^+K^-$	y_{CP}	2–3×10^{-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}
$D^0 \to K^0_S\pi^+\pi^-$	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 charm

Mode	Observable	$\Upsilon(4S)$ ($75\ \text{ab}^{-1}$)	$\psi(3770)$ ($300\ \text{fb}^{-1}$)
$D^0 \to K^+\pi^-$	x'^2	3×10^{-5}	
	y'	7×10^{-4}	
$D^0 \to K^+K^-$	y_{CP}	5×10^{-4}	
$D^0 \to K^0_S\pi^+\pi^-$	x	4.9×10^{-4}	
	y	3.5×10^{-4}	
	$\|q/p\|$	3×10^{-2}	
	ϕ	2°	
$\psi(3770) \to D^0\overline{D}^0$	x^2		$(1-2) \times 10^{-5}$
	y		$(1-2) \times 10^{-3}$
	$\cos\delta$		$(0.01-0.02)$



A golden mode from charm ?
Probably for CP measurements

Short summary

Some important related issues : Background generation.

- Sensitivity studies. NOW we have the SuperB FastSim

Most of the evaluations contained on the CDR were done simply extrapolating the BaBar available measurements « cum grano salis » Some sensitivity studies started in Valencia.

- Phenomenological studies on New Physics

In CDR *we defend physics program with some phenomenological New Physics studies, not really looking in details on different possible models*

First is to have a clear anthology of recent phenomenological analyses Have we missed something ?

- Theoretical uncertainties

In the CDR we consider the impact of these uncertainties on Radiative decays, Semileptonic decays , Non-perturbative QCD parameters (LQCD)…

Workshop on New Physics with SuperB

14th-17th April 2009

Warwick Working Groups

VERTICAL GROUPS

1) New Physics in Mixing and CP Violation.
2) Rare, Radiative and semi-leptonic decays.
3) Lepton Flavor Violation and New Physics Models.
4) CP and T Violation with Polarized Taus.
5) Charm Mixing and CP Violation in D decays.
6) Spectroscopy, exotica and other physics issues.

HORIZONTAL GROUPS

A. Phenomenology
- A1) MSSM
- A2) SUSY-GUTs (together with MSSM could be simply SUSY)
- A3) Little Higgs
- A4) Extra-dimensions
- A5) CKM analysis
- A6) Model independent/EFT analyses

B. Theoretical uncertainties
- B1) Radiative Decays
- B2) Rare Decays
- B3) Semileptonic Decays
- B4) Lattice QCD
- B5) Non-leptonic decays

C. Tools
- C1) Fast simulation
- C2) Event generators for implementation of BSM physics
- C3) Computing infrastructure for project: Grid, Farm and CPU cycle utilisation

This is the first workshop
with this structure
Lets' see how it works

Let’s have
a productive
Workshop !

BACKUP MATERIAL

Estimates of error for 2015

Hadronic matrix element	Current lattice error	6 TFlop Year	60 TFlop Year	1-10 PFl 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)**
$\mathcal{F}_{B \to D/D^* l\nu}$	4% (40% on $1-\mathcal{F}$)	2% (21% on $1-\mathcal{F}$)	1.2% (13% on $1-\mathcal{F}$)	**0.5% (5% on $1-\mathcal{F}$)**
$f_+^{B\pi}, \ldots$	11%	5.5 - 6.5%	4 - 5%	**2 – 3%**
$T_1^{B \to K^*/\rho}$	13%	----	----	**3 – 4%**