Theoretical Aspects
and
Specific Problems of Physics Analysis
at SuperB factories

(PROJECT:B_02 & B_03)

Emi KOU (LAL/IN2P3)

TYL meeting: LAPP (Annecy) 15-16th June 2010

Overview of the project

Project B_02 & B_03

Exp.

Project B_02

- Contributions to B physics
- Approved in 2006, 2007, 2008 (Hazumi/Stocchi) → 2010

Project B_03

Th.

- Investigation of the theoretical aspects of the flavour physics
- Approved in 2009 (Hashimoto/Kou) → 2010

2010

Project B_02& B_03

TH.&Exp.

- Theoretical Aspects and Specific Problems of Physics Analysis at SuperB factories (Hashimoto/Kou)

Members

*responsible

JP

FR

Th.

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S. Hashimoto,* T. Goto,
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Universities:
K. Tobe(Nagoya),
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Exp.

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Exp.

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Activity Report for 2009

~Project B_03~

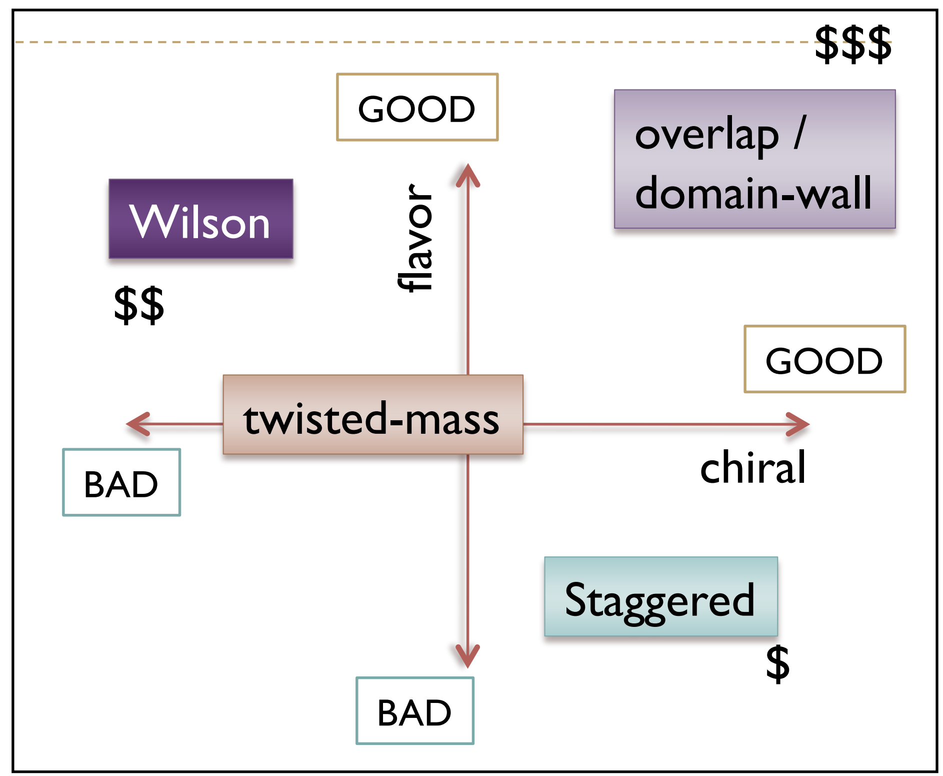
Japanese team visiting France I

~March 2010 (LAL): S. Hashimoto~

TYL workshop on Lattice QCD inputs to CKM fits

- **Day 1:** Review on the recent progress in the lattice QCD
- **Day 2:** Discussions on how to implement the lattice errors to the CKM fit (different approaches of the CKM fitters (by J. Charles) and UTfit (by A.Stocchi) presented).

Different formulation of fermions
→ Different errors in the final results



from S. Hashimoto

Japanese team visiting France I

~March 2010 (LAL): S. Hashimoto~

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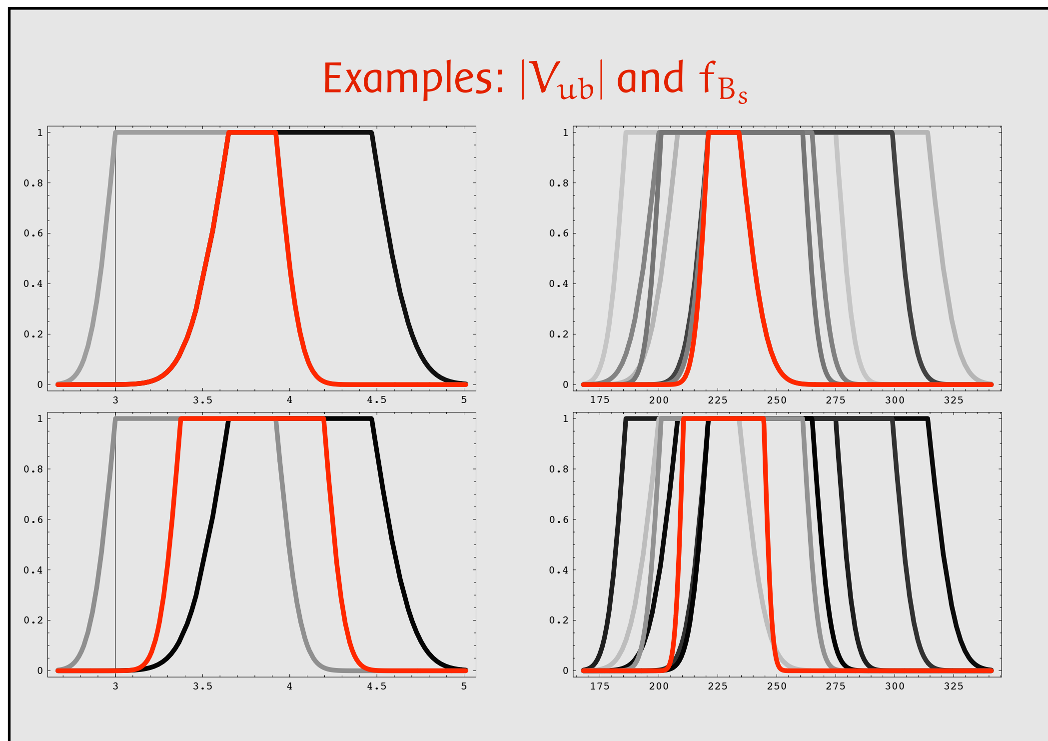
Statistical problems on how to deal with the lattice errors...



from J. Charles

Japanese team visiting France II

~Oct 2009 (LAL): T. Goto & Y. Shimizu, Dec 2009 (Frascati) T. Goto~

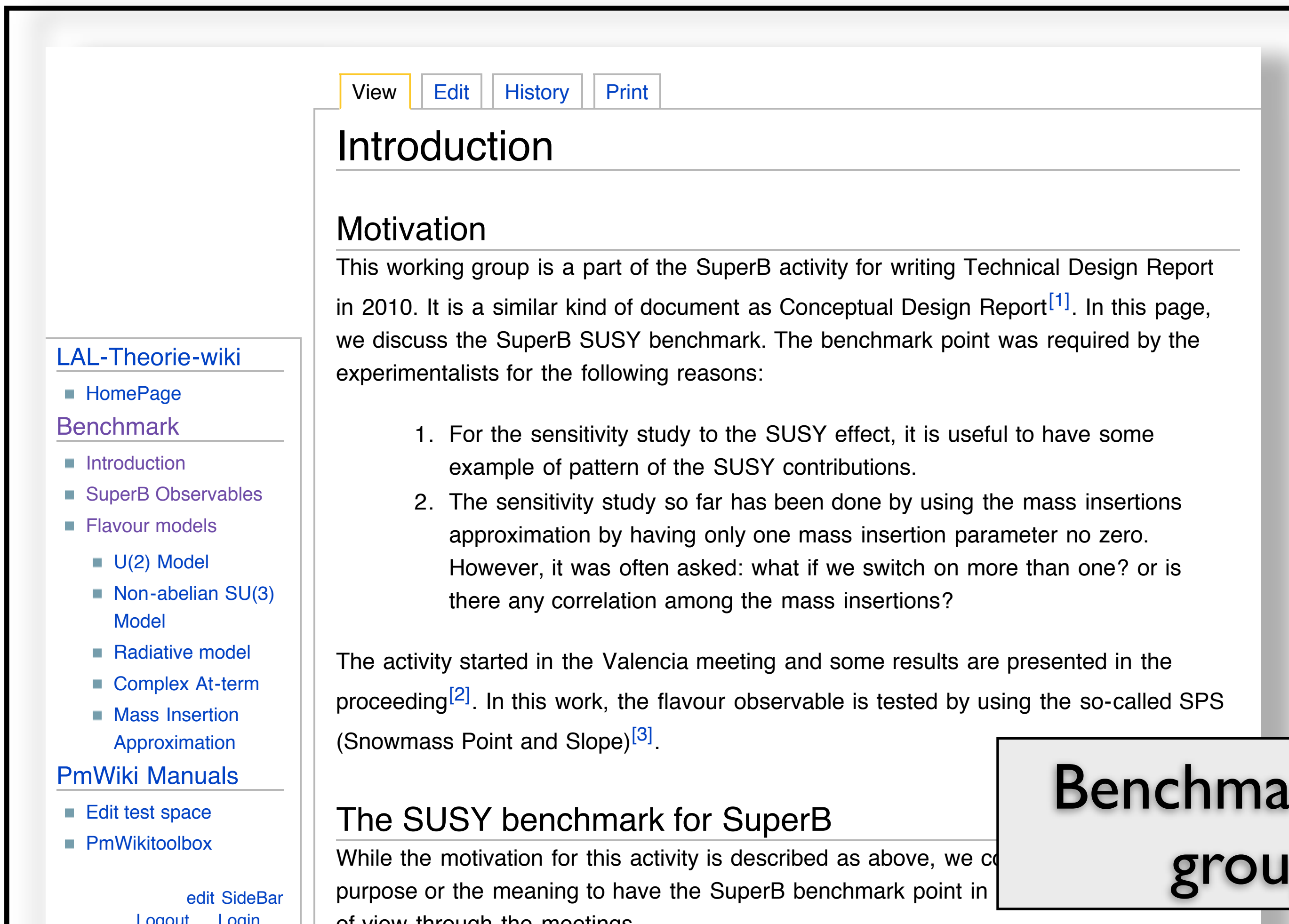
Working group on SUSY benchmark points for SuperB factories

- **Oct 2009 :** Working group on clarifying the role of the SuperB factories in order to pin down the parameter space of SUSY model.
- **Dec 2009 :** SUSY flavour models to present the interplay of the different SuperB observables.

Japanese team visiting France II

~Oct 2009 (LAL): T. Goto & Y. Shimizu, Dec 2009 (Frascati) T. Goto~

Working group on SUSY benchmark points for SuperB factories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LAL-Theorie-wiki
- HomePage

Benchmark
- Introduction
- SuperB Observables
- Flavour models
  - U(2) Model
  - Non-abelian SU(3) Model
  - Radiative model
  - Complex At-term
  - Mass Insertion Approximation

PmWiki Manuals
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Introduction

Motivation

This working group is a part of the SuperB activity for writing Technical Design Report in 2010. It is a similar kind of document as Conceptual Design Report[1]. In this page, we discuss the SuperB SUSY benchmark. The benchmark point was required by the experimentalists for the following reasons:

1. For the sensitivity study to the SUSY effect, it is useful to have some example of pattern of the SUSY contributions.
2. The sensitivity study so far has been done by using the mass insertions approximation by having only one mass insertion parameter no zero. However, it was often asked: what if we switch on more than one? or is there any correlation among the mass insertions?

The activity started in the Valencia meeting and some results are presented in the proceeding[2]. In this work, the flavour observable is tested by using the so-called SPS (Snowmass Point and Slope)[3].

The SUSY benchmark for SuperB

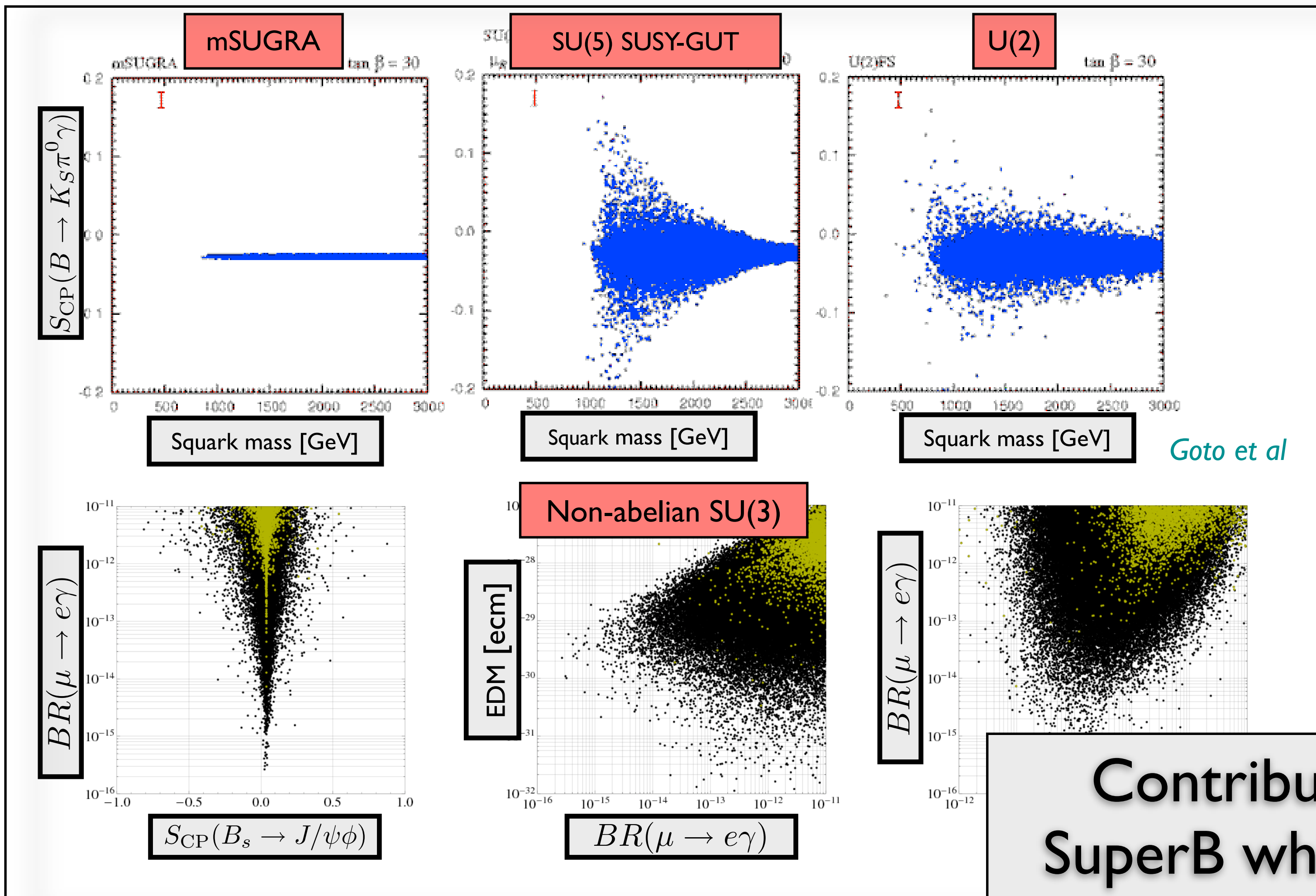
While the motivation for this activity is described as above, we c
purpose or the meaning to have the SuperB benchmark point in

Benchmark working group Wiki

Japanese team visiting France II

~Oct 2009 (LAL): T. Goto & Y. Shimizu, Dec 2009 (Frascati) T. Goto~

Working group on SUSY benchmark points for SuperB factories



Contribution to SuperB white paper

French team visiting Japan I

~Feb 2010 (KEK): B.Blossier, S.Descotes-Genon, E.Kou, A.Tayduganov ~

Informal seminars on Lattice QCD

- **Subject 1:** The chiral perturbation theory and lattice (S. Descotes-Genon)
- **Subject 2:** European Lattice QCD activities (B.Blossier)
- **Subject 3:** Baryon spectroscopy on Lattice QCD (B.Blossier)

French team visiting Japan I

~Feb 2010 (KEK): B.Blossier, S.Descotes-Genon, E.Kou, A.Tayduganov ~

Lectures at the BELLE analysis school

- **Lecture 1:** Non- leptonic B decays into two mesons (S. Descotes-Genon)
- **Lecture 2:** SUSY CP/Flavour problem (E. Kou)
- **Lecture 3:** $b \to s\gamma$ (e.g. $B \to K\pi\pi\gamma$) (E. Kou)

Participation: B. Blossier and A. Tayduganov

Project and Plan for 2010

~Theoretical Aspects and
Specific Problems of Physics Analysis
at SuperB factories~

I. Theoretical aspects

Our project aims at...

- Reduction of the theoretical uncertainties: very important to justify the SuperB projects
- New physics: clarifying the target and the sensitivity is important for SuperB projects

- The activity 2009 was very useful for the SuperB community.
- We will continue those activities (SUSY benchmark, lattice QCD relation and discussions with fitters and more...) and further enforce the theory relation between France and Japan.

II. Specific problems for physics analysis at SuperB

- The SuperB factories aim at a 50-100 times higher luminosity than the current machines.
- Two SuperB projects are waiting for the full approval.

Our project aims at...

- Discussions on new ideas in theory: possible new observables at the SuperB factories.
- Discussions on specific analysis problem: experiences from BELLE/BABAR to SuperB

II. Specific problems for physics analysis at SuperB

B physics @ Y(4S)

Variety of measurements for any observable

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 (∗)
$\|V_{cb}\|$ (exclusive)	4% (∗)	1.0% (∗)
$\|V_{cb}\|$ (inclusive)	1% (∗)	0.5% (∗)
$\|V_{ub}\|$ (exclusive)	8% (∗)	3.0% (∗)
$\|V_{ub}\|$ (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

SuperB Observables!

Example of « SuperB specifics »

- inclusive in addition to exclusive analyses
- channels with π^0, γ's, ν, many Ks…

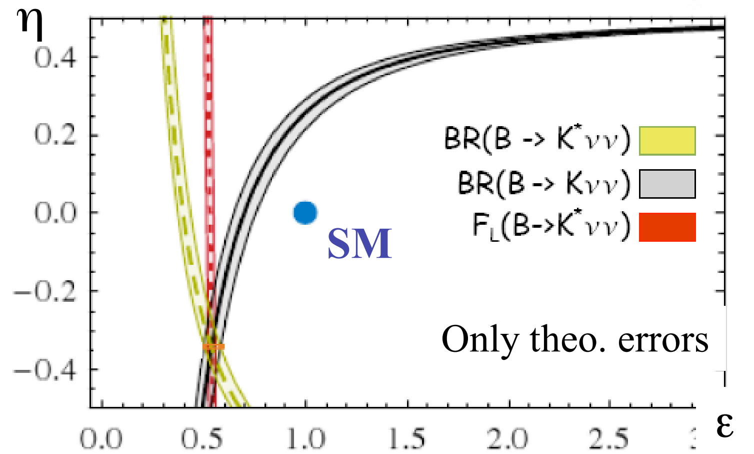
from A. Stocchi

Analysis Examples...

B ➛ K$^{(*)}\nu\nu$ - Z penguins and Right-handed current searches

by A.Perez,
A. Stocchi,
N.Arnaud,
L.Burmistrov

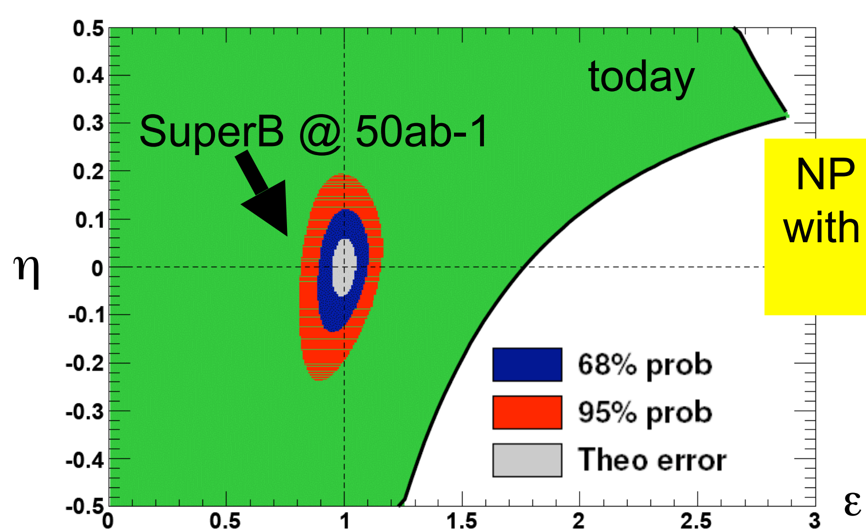
$$\epsilon = \frac{\sqrt{|C_L^\nu|^2 + |C_R^\nu|^2}}{|(C_L^\nu)^{SM}|}, \qquad \eta = \frac{-\mathrm{Re}\,(C_L^\nu C_R^{\nu *})}{|C_L^\nu|^2 + |C_R^\nu|^2}$$



With errors obtained so far from FastSim and detector + FPID

Br(B→ K*νν) Br(B→ Kνν)

Longitudinal polarization should be added

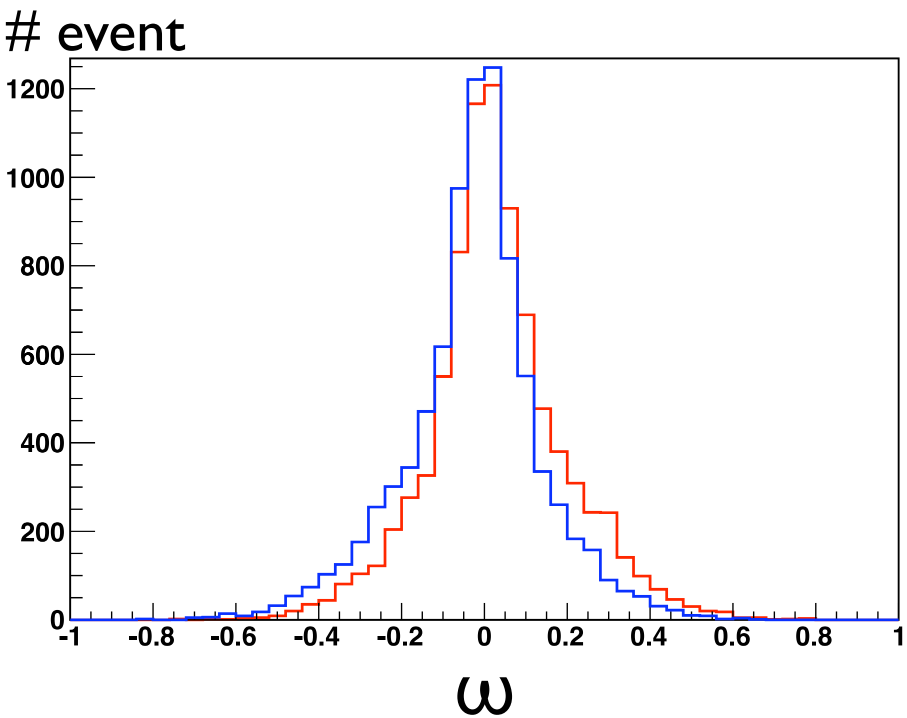


NP potential from golden channel with SuperB and improved detector (..many more for TDR)

Analysis Examples...

Photon polarization determination in $B \to K_1 \gamma$ decay

by E.Kou, A.Tayduganov, A.Le Yaouanc



An optimized variable ω can be used for this analysis, which can simplify the analysis and at the same time, can increase the sensitivity.

Photon in $b \to s\gamma$ process is predicted to be left-handed polarized due to the nature of the weak interaction in SM.

⇩

However, it has never been confirmed at a high precision.

⇩

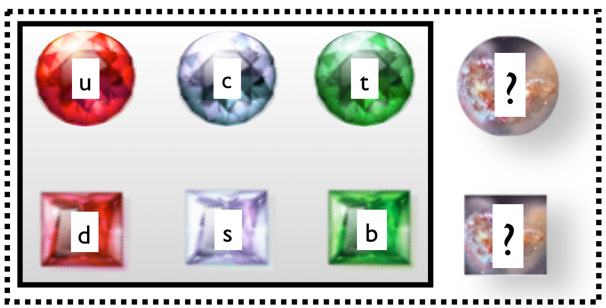
Sensitivity study of the photon polarization for the recently observed $B \to K_1(1270)\gamma$ decay channel

Analysis Examples...

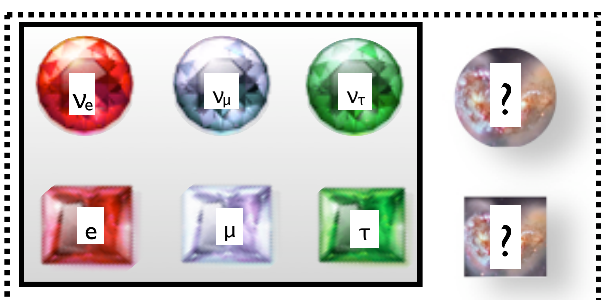
Role of D-D mixing to constrain 4th generation model

by E.Kou, N.Kosnic

Quark



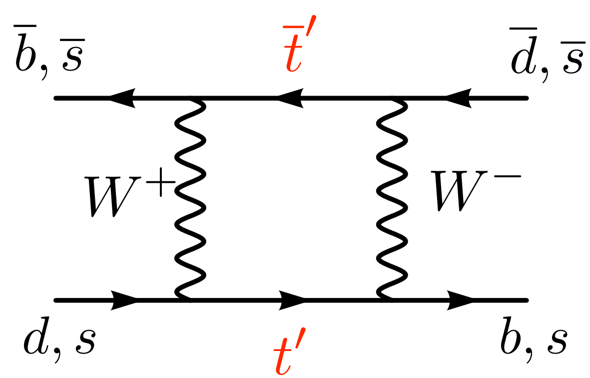
Lepton



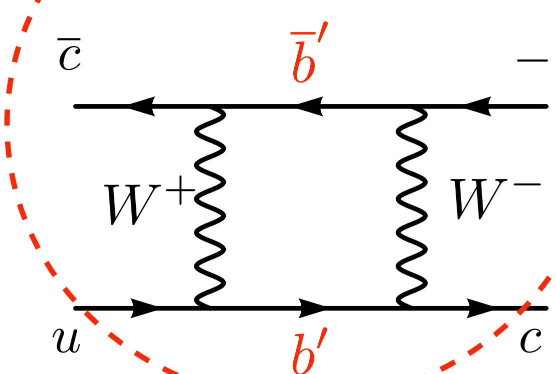
Number of generation is not a requirement of the standard model. There might be 4th generation!

4x4 CKM matrix
Extra 3 angles & 2 phases

$B_{d/s}$-$B_{d/s}$/K-K mixing



D-D mixing



Electroweak Precision measurement &
Direct search

$$\boxed{m_{t'},\ m_{b'}}$$

Conclusions

- This proposal is the combined project B_02 (2006,2007,2008) & B_03 (2009).
- We reported the theory co-operation activity in 2009.
- We would like to continue this activity in 2010 in order to further enforce the French-Japan theory co-operation.
- For 2010, we propose an additional project to discuss the SuperB physics case and the specific analysis problem.