THEORETICAL ASPECTS OF FLAVOUR PHYSICS
(PROJECT: B_02)

Emi KOU (LAL/IN2P3)

FJPPL meeting: Tsukuba, 20-21st May 2009

Members and expertise

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B. Blossier,
S. Descotes-Genon
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* leaders

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B/D/K physics

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Lattice QCD

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Beyond SM

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ν and LFV

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FJ corporation in flavour physics

JP

SuperB
(SuperKEKB)
J-PARC
Lattice QCD

FR

SuperB
(Super Flavour Factory)
LHCb
Lattice QCD

ATLAS
T2K
Double-Chooz

FR+JP

FJ corporation in flavour physics

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SuperB
(SuperKEKB)
J-PARC
Lattice QCD

- SuperB Physics working groups:
  - SuperKEKB physics WG
  - New physics with SuperB
  (Super Flavour Factory physics TDR)

FR

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- SuperB Physics working groups:
  - SuperKEKB physics WG
  - New physics with SuperB (Super Flavour Factory physics TDR)
- CERN Working group:
  - Interplay of collider and flavour physics
  - Flavour in the era of the LHC

FR

SuperB
(Super Flavour Factory)
LHCb
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(SuperBelle)
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Lattice QCD

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  - Fla...

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SuperB
(Super Flavour Factory)
LHCb
Lattice QCD

✓ **Our project aims at further strengthening the FJ corporation in theoretical physics via FJPPL.**

ATLAS
T2K
Double-Chooz

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Physics beyond SM at SuperB factory

In the case of SUSY...

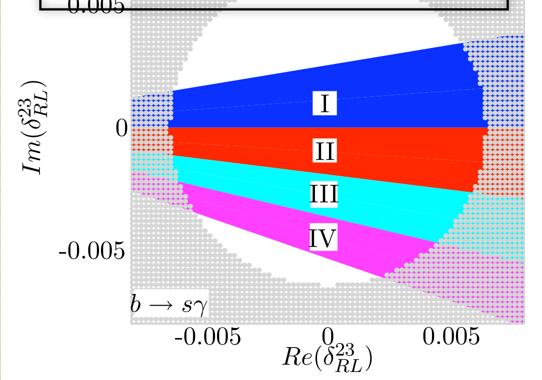
✓ Origin of super-particle masses (SUSY breaking) is unknown
✓ Flavour physics can help to distinguish different SUSY breaking mechanisms.

→ *Examples of model-independent and -dependent analysis*

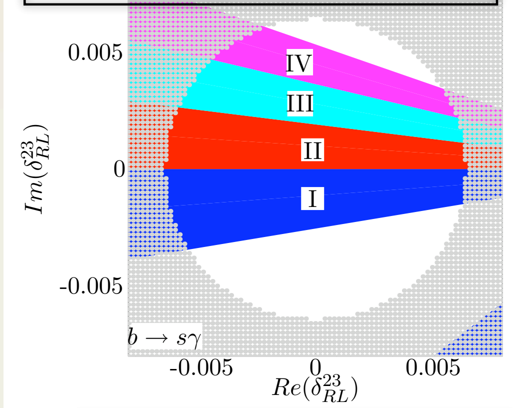
SUSY model independent

$$\mathcal{L}_{\rm soft}^{\rm MSSM} \supset \tilde{\bar{u}}_R \mathbf{m}^2_{\mathbf{\bar{u}}} \tilde{\bar{u}}_R^\dagger + \tilde{\bar{d}}_R \mathbf{m}^2_{\mathbf{\bar{d}}} \tilde{\bar{d}}_R^\dagger + \tilde{Q}_L^\dagger \mathbf{m}^2_{\mathbf{Q}} \tilde{Q}_L + v_u \tilde{\bar{u}}_R \mathbf{a_u} \tilde{Q}_L + v_d \tilde{\bar{d}}_R \mathbf{a_d} \tilde{Q}_L$$

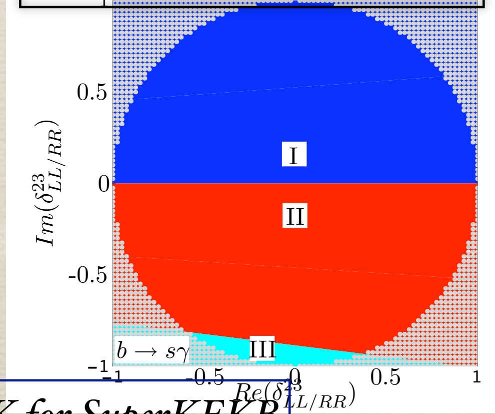
δ_{RL} bound for $\Delta S_{\phi K_s}$



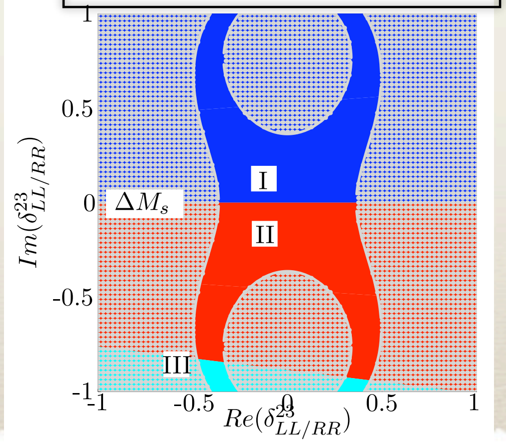
δ_{RL} bound for $\Delta S_{\eta' K_s}$



δ_{LL} bound for $\Delta S_{\phi K_s}$



δ_{LL} bound for ΔM_s



$\Delta S_{\phi K_s} \equiv S_{J/\psi K_s} - S_{\phi K_s}$

$\Delta S_{\eta' K_s} \equiv S_{J/\psi K_s} - S_{\eta' K_s}$

I: $0 < \Delta S < 0.2$
II: $-0.2 < \Delta S < 0$
III: $-0.4 < \Delta S < -0.2$
IV: $-0.6 < \Delta S < -0.4$

HFAG:

$\Delta S_{\phi K_s} = -0.22 \pm 0.18$

$\Delta S_{\eta' K_s} = -0.07 \pm 0.07$

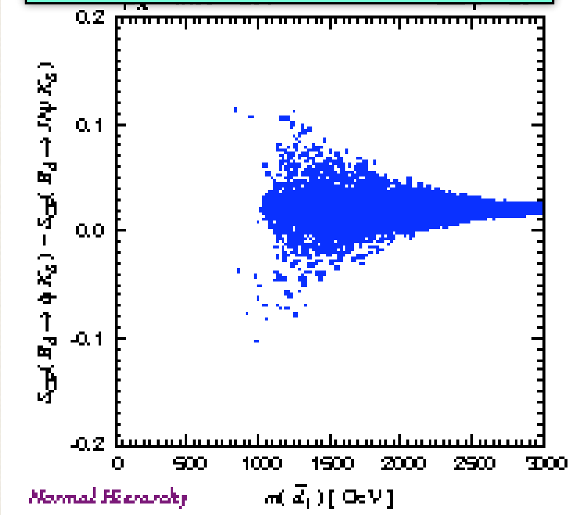
E.K for SuperKEKB

SUSY SU(5) with ν_R

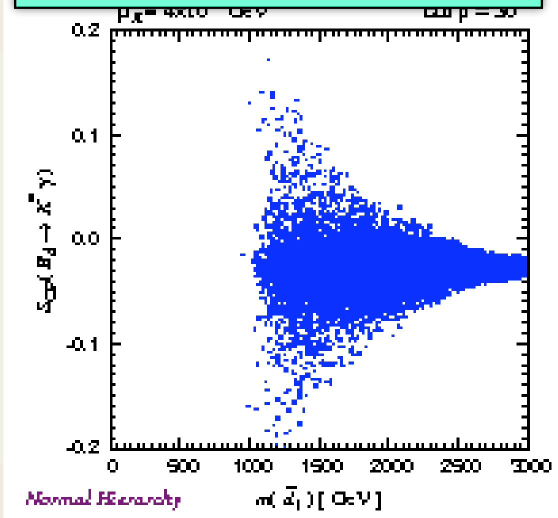
$$W = \frac{1}{4} Y^u_{ij} 10_i 10_j 5_H + \sqrt{2} Y^d_{ij} 10_i \bar{5}_j 5_H + Y^u - ij \bar{5}_i \overline{N}_j 5_H + M_{N ij} \overline{N}_i \overline{N}_j$$

$$10_i = (Q, \overline{U}, \overline{E}), \quad \bar{5}_i = (\overline{D}, L), \quad 5_H = (H_C, H_2), \quad \bar{5}_H = (\overline{H}_C, H_1)$$

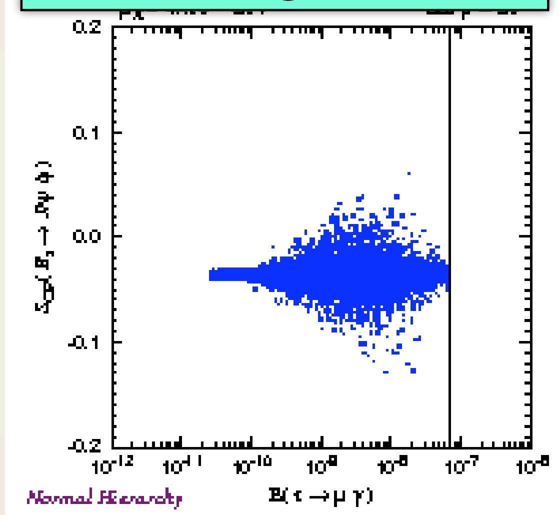
$\Delta S_{\phi K_S}$ vs squark mass



$S_{K^*\gamma}$ vs squark mass



Bs mixing vs $\tau \to \mu\gamma$



SuperB: $\Delta S_{\phi K_S}$ and $S_{K^*\gamma}$
5-10 % sensitivity

LHCb: Bs mixing
a few % sensitivity
SuperB: $\tau \;\; \mu\gamma$
Br ~ 10^{-9}

Okada et al for SuperB

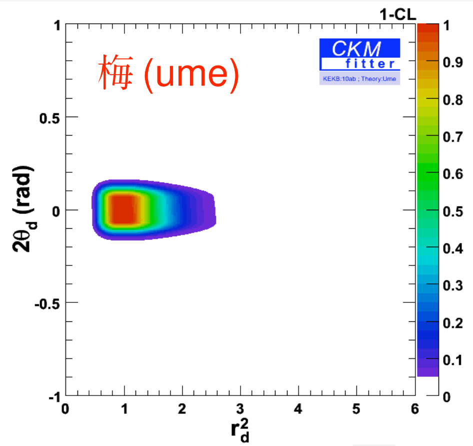
Theoretical uncertainties and Lattice QCD

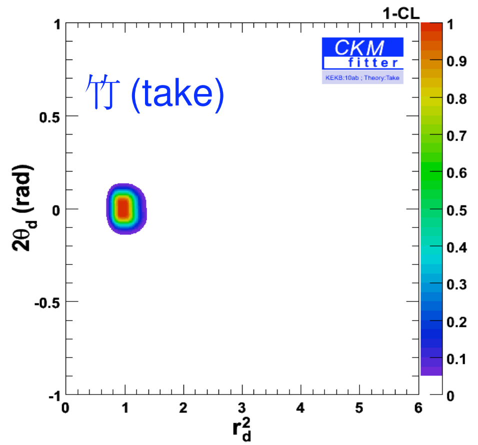
talk by S T'Janpens at FJPPL08

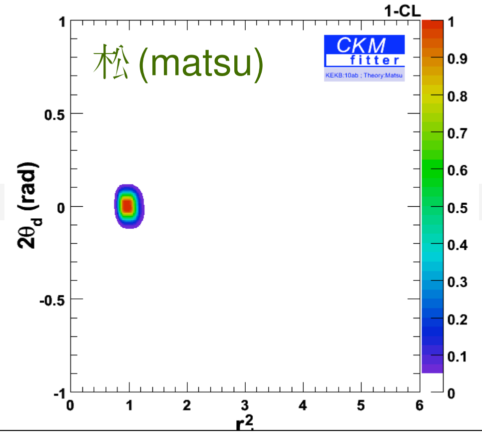
as an example...

New Physics in Mixing [$M = M_{SM} r_d^2 \exp(-i2\theta_d)$]

10 ab^{-1}







	$\sigma(r_d^2)$	$\sigma(2\theta_d)$
梅 Ume	42%	5.9°
竹 Take	17%	4.3°
松 Matsu	13%	3.3°

*Improvement in f_B and B calculations is the key in the model independent NP search.

Theoretical uncertainties and Lattice QCD

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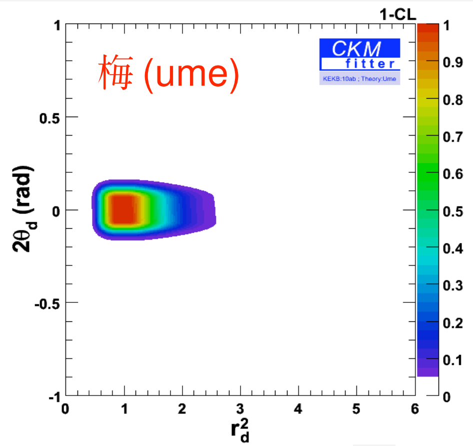
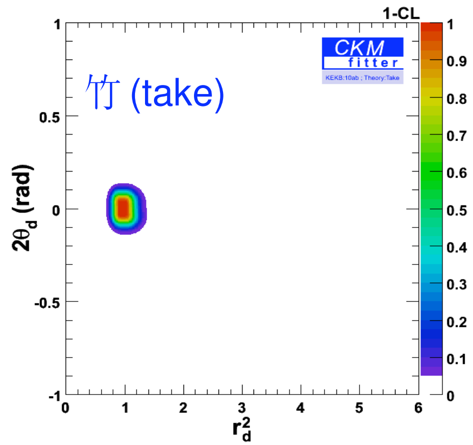
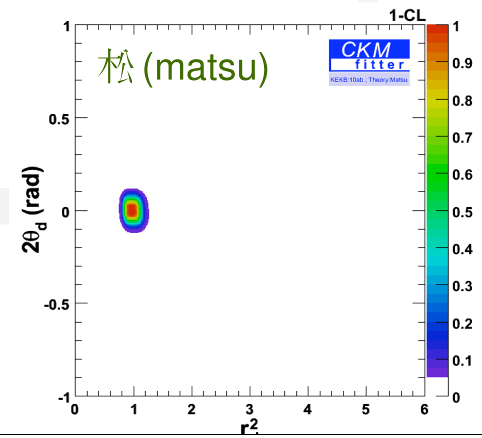






	$\sigma(r_d^2)$	$\sigma(2\theta_d)$
梅		
竹		
松		

*Impr

in the

✓ Improvements in Lattice error are equally important for SuperB result!

Theoretical uncertainties and Lattice QCD

Estimates of error for 2015

V.Lubic for SuperB

Hadronic matrix element	Current lattice error	6 TFlop Year	60 TFlop Year	1-10 PFl  Year
$f_+^{K\pi}(0)$	0.9% (22% on $1\text{-}f_+$)	0.7% (17% on $1\text{-}f_+$)	0.4% (10% on $1\text{-}f_+$)	**< 0.1% (2.4% on $1\text{-}f_+$)**
$\hat{B}_K$	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 $1\text{-}\mathcal{F}$)	2% (21% on $1\text{-}\mathcal{F}$)	1.2% (13% on $1\text{-}\mathcal{F}$)	**0.5% (5% on $1\text{-}\mathcal{F}$)**
$f_+^{B\pi}, \ldots$	11%	5.5 - 6.5%	4 - 5%	**2 – 3%**
$T_1^{B\to K^*/\rho}$	13%	----	----	**3 – 4%**

We will discuss more in detailed on the systematic error in the framework of JFPPL.

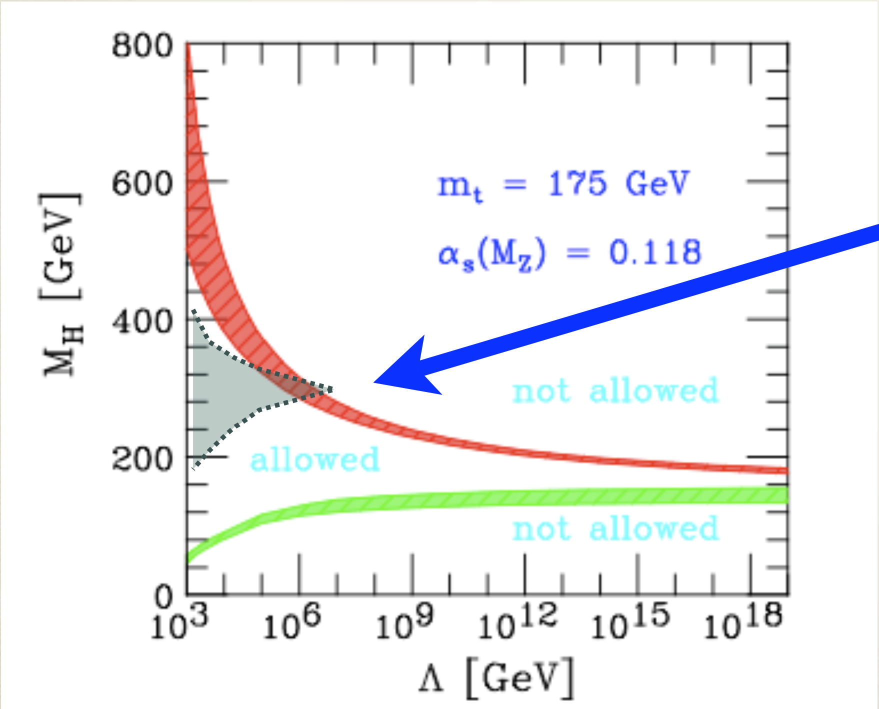
Conclusions

* FJPPL will be a great help for strengthening the France-Japan corporation in theoretical physics.
* There has been various joint works in SuperB physics case studies, targeting to clarify the physics reach of these machines. Within our project B_02, we will further scrutinize these works.
* We are also discussing more new ideas. It is clear that a closer relation will help us to realize such ideas.

Backup

More topics discussed...

- 4th generation and strongly coupled theory



- Strongly coupled region: non-perturbative computation (such as Lattice) is needed.

Contribution to CERN LHC/LC Workshop by E.K and F. Richard

Some work already done by the KEK lattice group

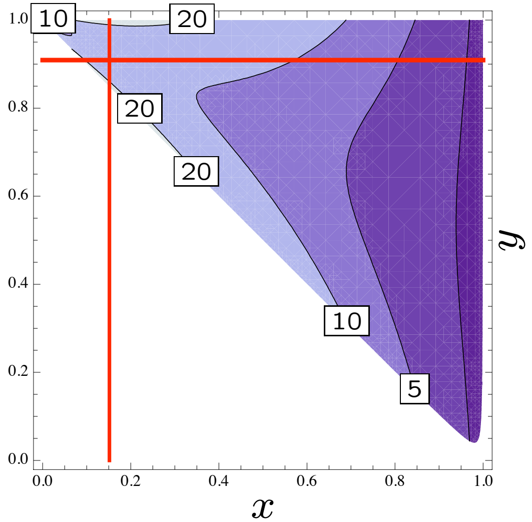
Soft photon issue of B→μν

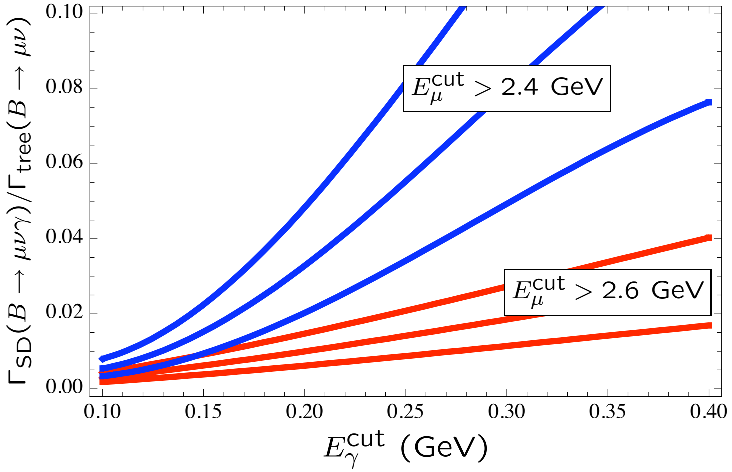
✓Possible large background due to the soft photon

☞ We show our result depending on the energy cut:

$$x = \frac{2E_\gamma}{m_B}, \quad y = \frac{2E_\mu}{m_B}$$

$d^2\Gamma_{SD}(B \to \mu\nu\gamma)/\Gamma_{tree}(B \to \mu\nu)$





☞ The structure-dependent contribution leads to a significant background to $B \to \mu\nu$. However, this can be resolved if one can improve the photon and muon energy sensitivity.

talk by E.K at KEK theory semianr

More topics discussed...

- Flavour and high p_T interplay:

Benchmark for flavour physics (c.f IRC requirement):
(i) Providing inputs to the sensitivity studies and geometry decision making

SPS1*a* :	$m_0 = 100\text{GeV}$,	$m_{1/2} = 250\text{GeV}$,		(7)
	$A_0 = -100\text{GeV}$,	$\tan\beta = 10$,	$\mu > 0$	
SPS4 :	$m_0 = 400\text{GeV}$,	$m_{1/2} = 300\text{GeV}$,		
	$A_0 = 0$,	$\tan\beta = 50$,	$\mu > 0$,	
SPS5 :	$m_0 = 150\text{GeV}$,	$m_{1/2} = 300\text{GeV}$,		
	$A_0 = -1000$,	$\tan\beta = 5$,	$\mu > 0$.	

	SPS1a	SPS4	SPS5
$\mathcal{R}(B \to X_s\gamma)$	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
$\mathcal{R}(B \to K\nu\bar{\nu})$	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
$\mathcal{R}(K \to \pi^0\nu\bar{\nu})$	0.973 ± 0.001	0.977	0.994 ± 0.001

TDR:
(i) Can we find a *nice point* for Super flavour factory (non-MFV? non-mSUGRA type)?

➡ Theorists contributions are welcome!

talk by E.K at SuperB Warick meeting