SuperKEKB

May 16, 2006

Flavour Physics at the Era of the LHC
@CERN

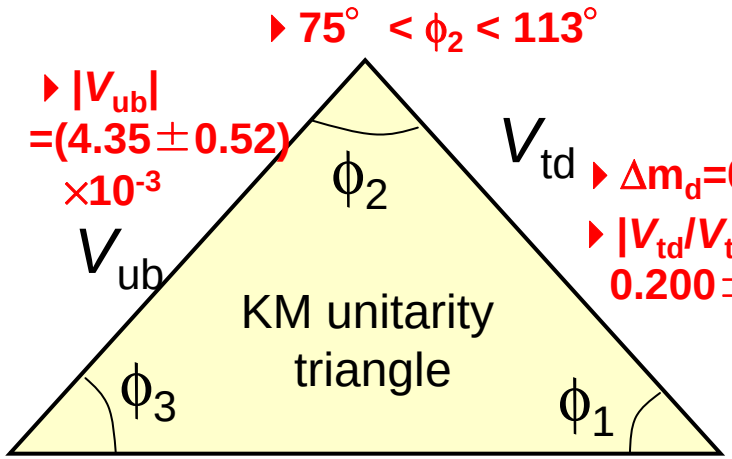
Masa Yamauchi
KEK

Outline

- Introduction
- Achievements of the *B* factories and the next step
- SuperKEKB: physics
- SuperKEKB: detector and schedule
- Situation at KEK and internationalization of the project
- Summary

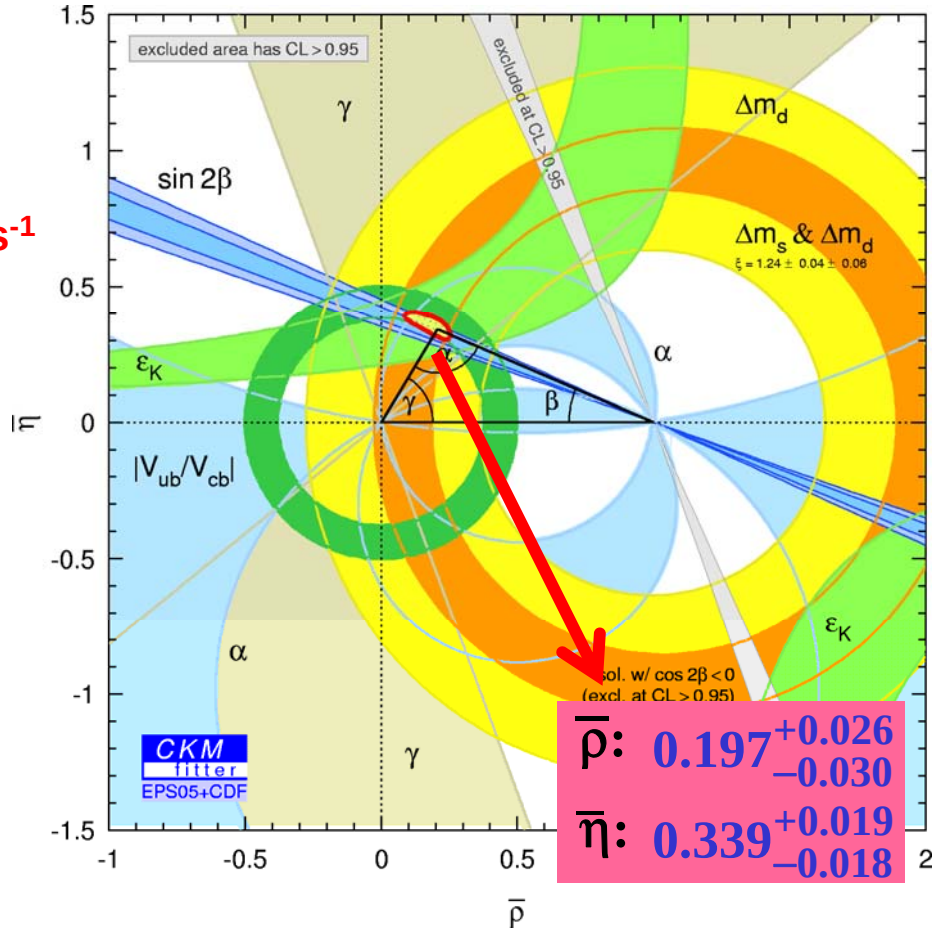
Achievements of the *B* Factories

Quantitative confirmation of the KM theory



- $75^\circ < \phi_2 < 113^\circ$
- $|V_{ub}| = (4.35 \pm 0.52) \times 10^{-3}$
- $\Delta m_d = 0.511 ps^{-1}$
- $|V_{td}/V_{ts}| = 0.200 \pm 0.046$
- $22^\circ < \phi_3 < 113^\circ$
- $\sin 2\phi_1 = 0.728 \pm 0.061$
- $|V_{cb}| = (4.08 \pm 0.27) \times 10^{-2}$

(Belle, 2005)

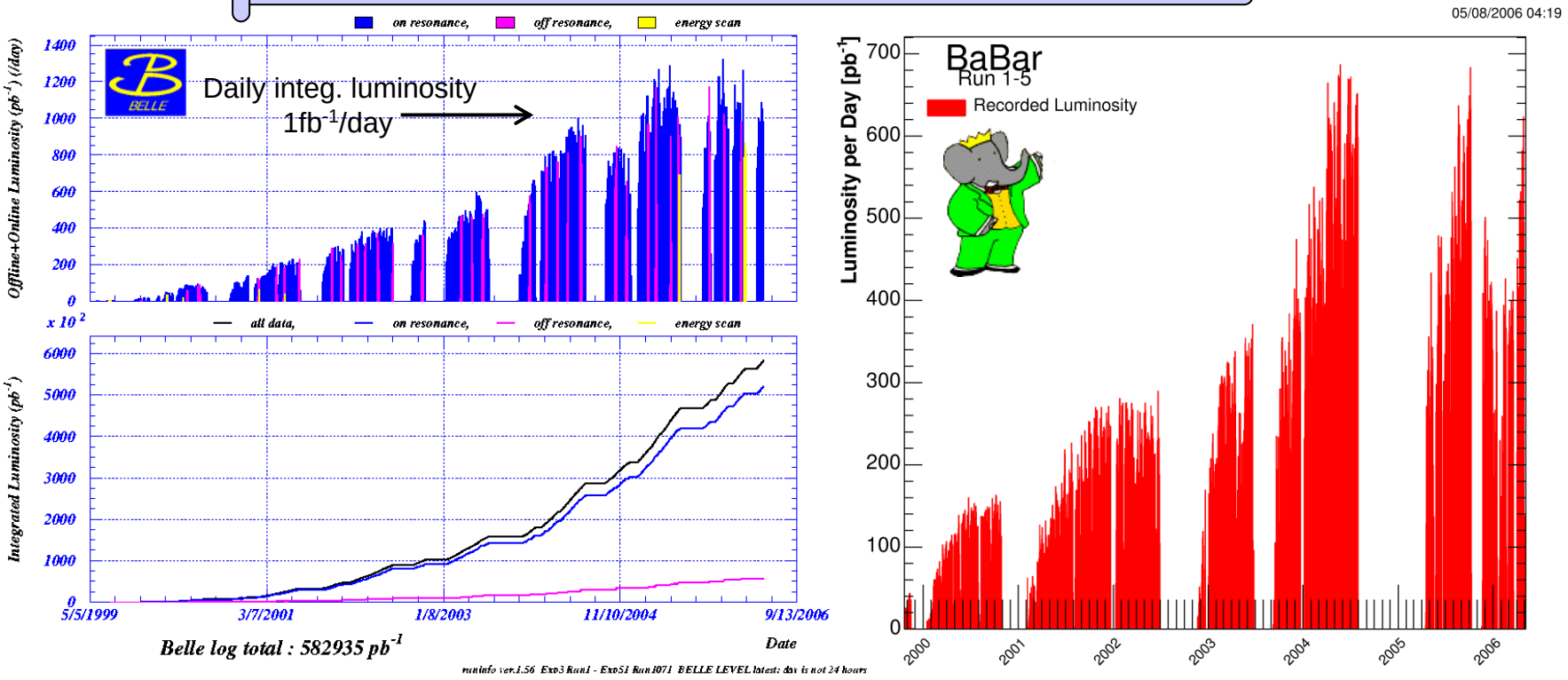


$\bar{\rho}$: $0.197^{+0.026}_{-0.030}$

$\bar{\eta}$: $0.339^{+0.019}_{-0.018}$

Another important achievement

Asymmetric e^+e^- collider with $L > 10^{34}$



- Success of KEKB and PEP-II enabled us to design a new e^+e^- *B* factory with much higher L_{peak}.

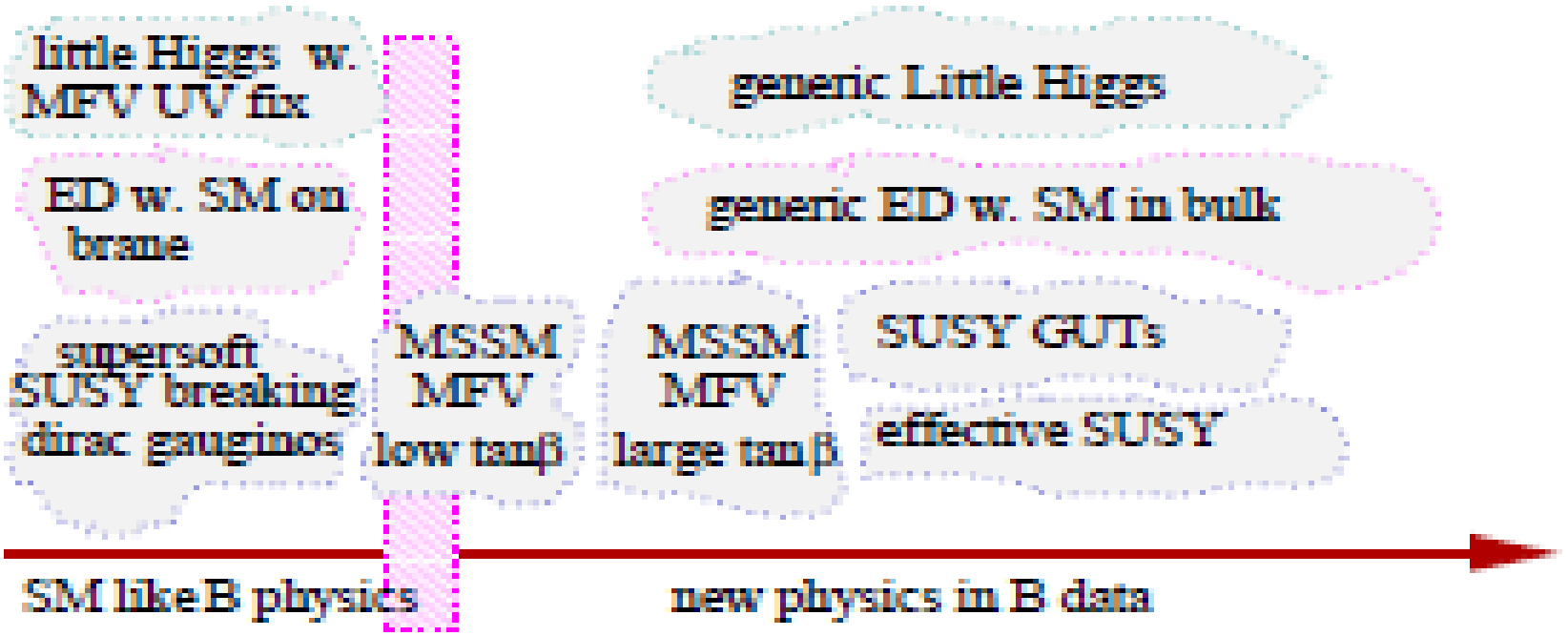
What is next with *B* physics?

- If new physics at O(1)TeV…
  - It is natural to assume that the effects are seen in $B/D/\tau$ decays.
  - Flavour structure of new physics?
  - CP violation in new physics?
  - These studies will be useful to identify mechanism of SUSY breaking, if NP=SUSY.

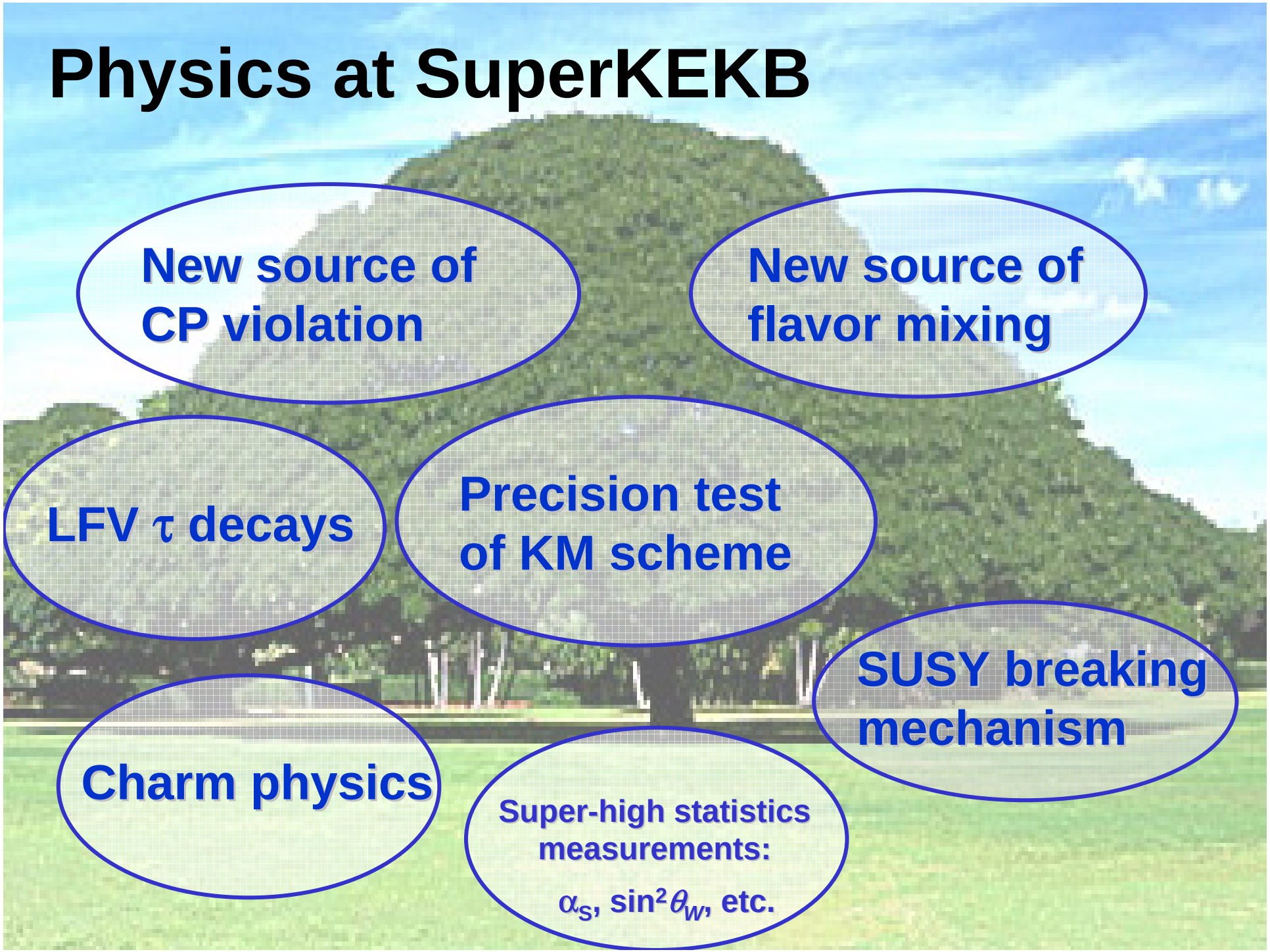
- Otherwise…
  - Search for deviations from SM in flavor physics will be one of the best ways to find new physics.

New physics effect in *B* decays

G.Hiller



Likelihood for the effects of new physics to be seen in *B* decays.


Physics at SuperKEKB
New source of CP violation
New source of flavor mixing
LFV τ decays
Precision test of KM scheme
SUSY breaking mechanism
Charm physics
Super-high statistics measurements:
α_S, $\sin^2\theta_W$, etc.

Precision test of KM scheme

50 ab^{-1}

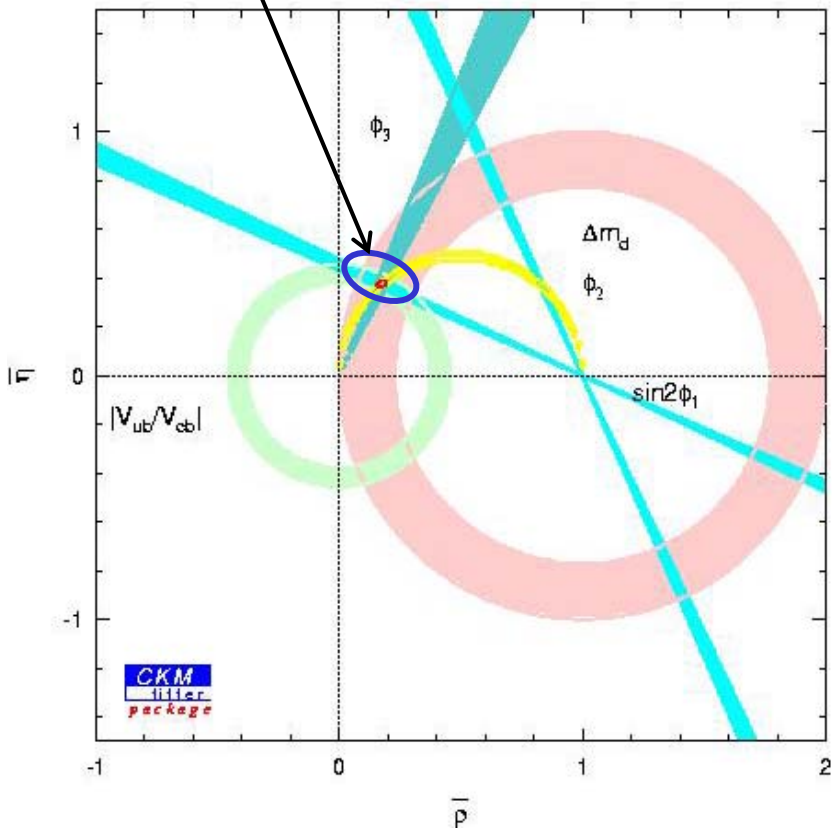
$\Delta \sin 2\phi_1 = 0.014$

$\Delta(f_B\sqrt{B_d}) = 0.005 \pm 0.015$

$\Delta |V_{ub}| = 4.4\%$

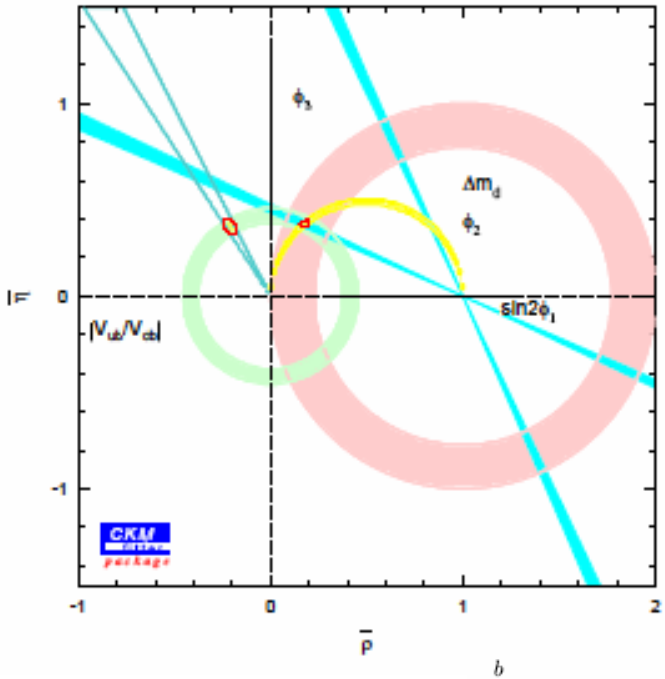
$\Delta\phi_3 = 1.2^\circ$

Result with 0.3fb^{-1}

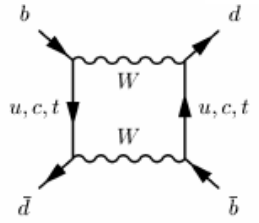


or

If tree-level and $b \to d$ mixing processes give inconsistent results,



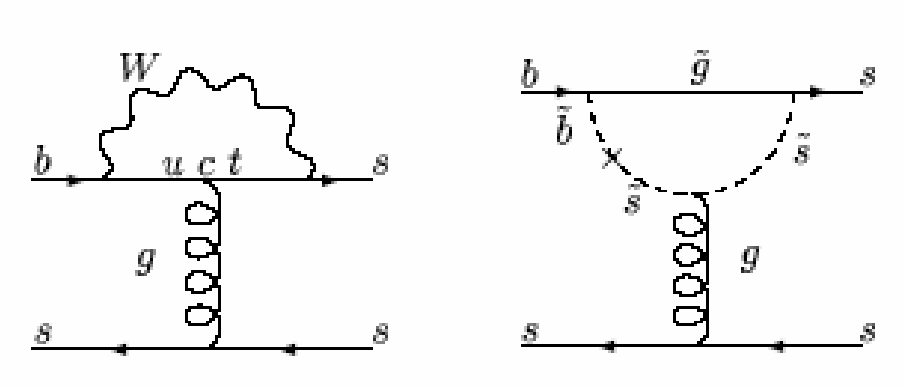
…indicates something new in



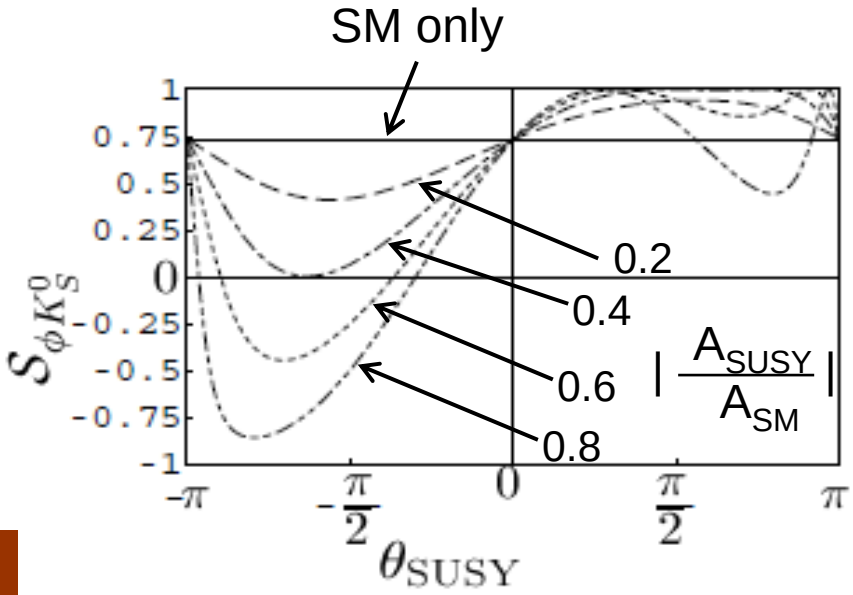
Search for new CP phases

In general, new physics contains new sources of flavor mixing and CP violation.

- In SUSY models, for example, SUSY particles contribute to the $b \to s$ transition, and their CP phases change CPV observed in $B \to \phi K$, $\eta' K$ etc.



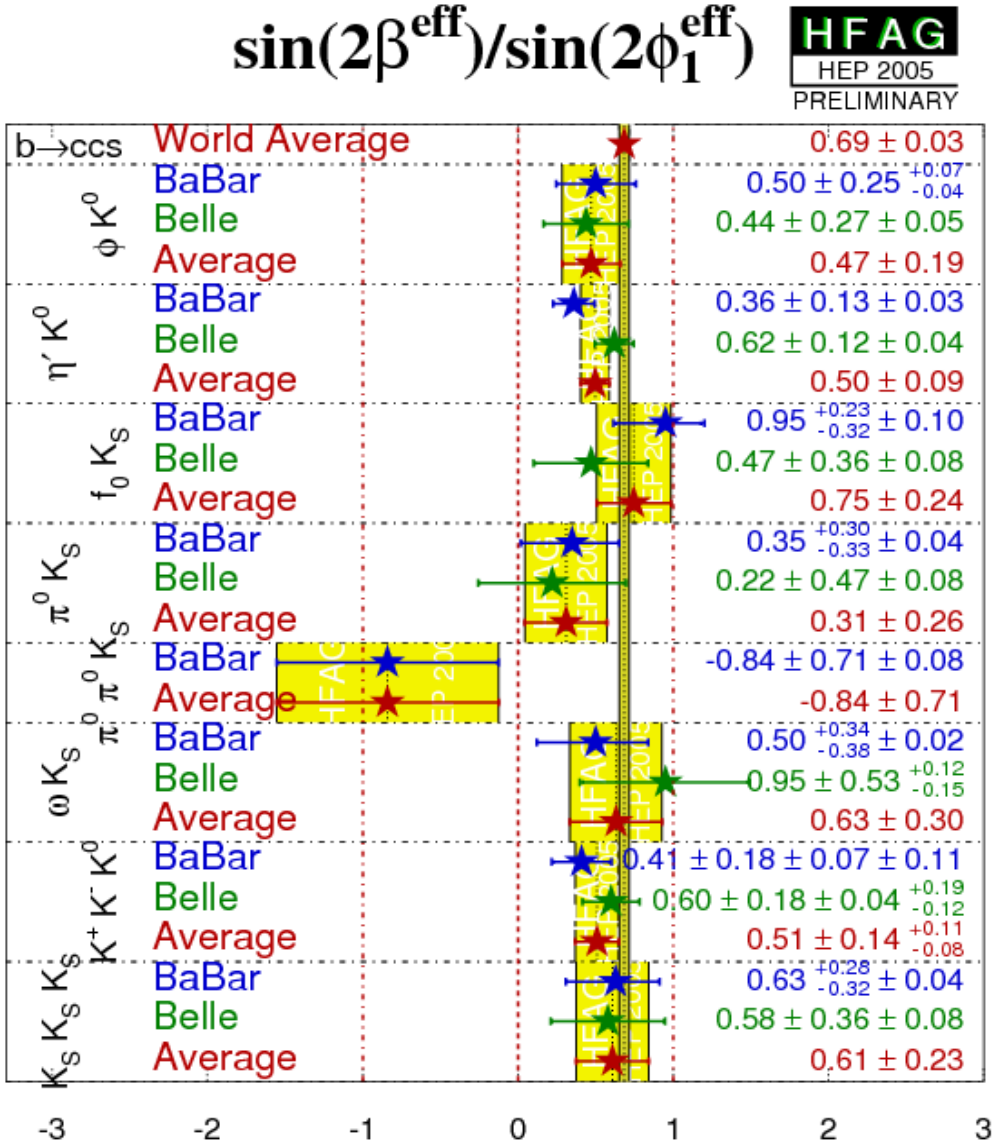
SM SUSY contribution

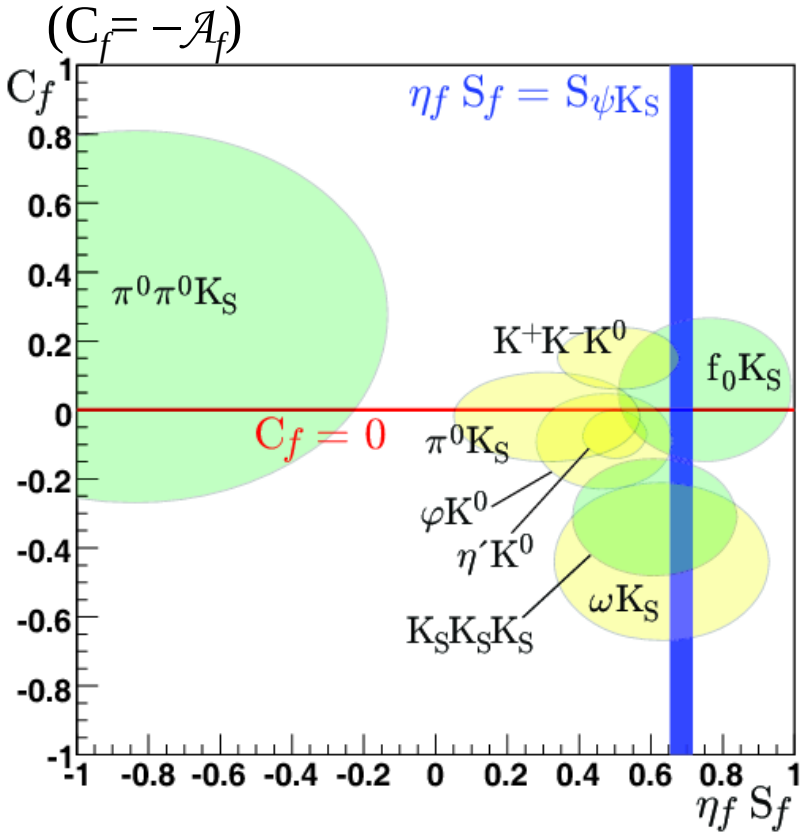


Effect of SUSY phase θ_{SUSY} on CPV in $B \to \phi K$ decay

In general, if SUSY is present, the *s*-quark mixing matrix contains complex phases just as in the Kobayashi-Maskawa matrix.

A possible hint for NP: $b \to s\bar{q}q$

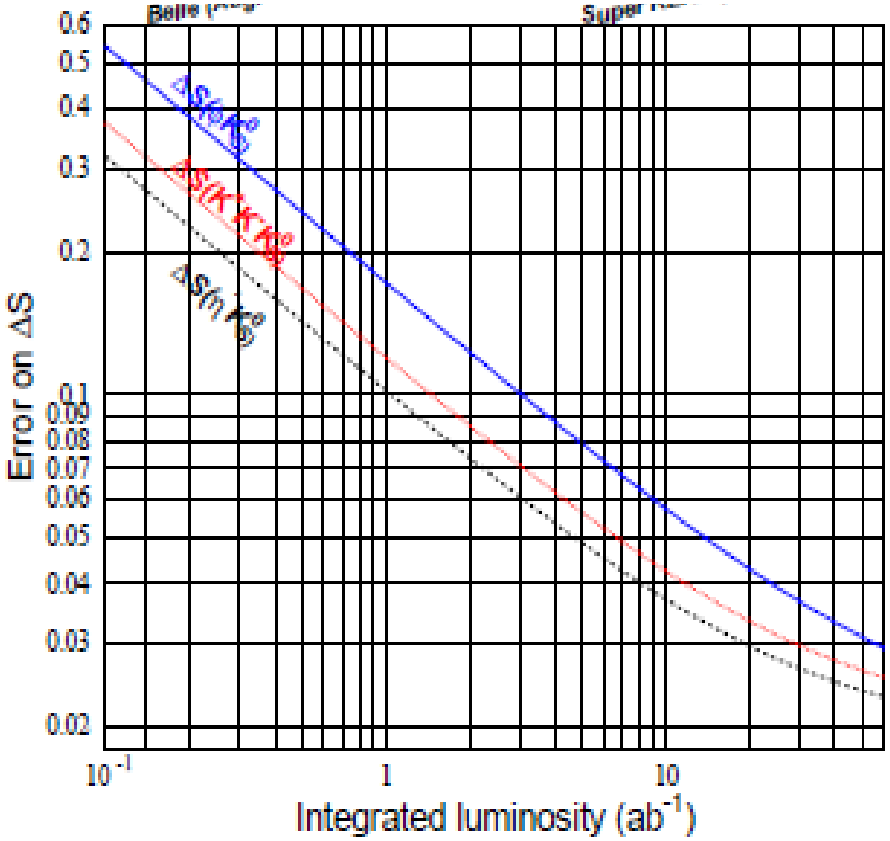




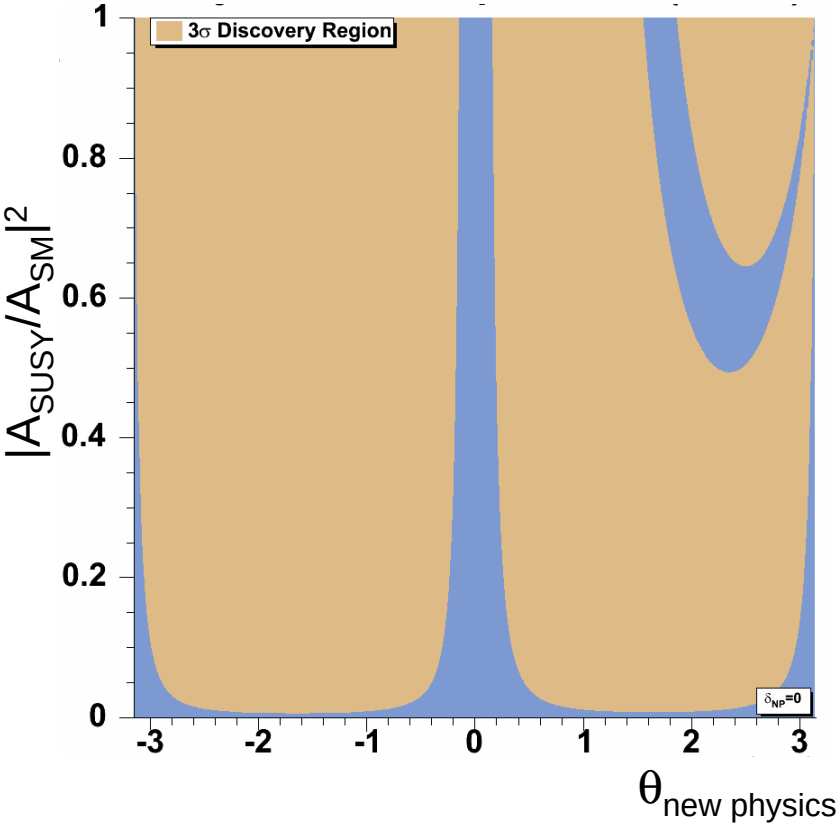
Naïve average
$\sin 2\phi_1^{\text{eff}} = 0.5 \pm 0.09$
(2.6σ from $\sin 2\phi_1$)

Sensitivity to new CP phases

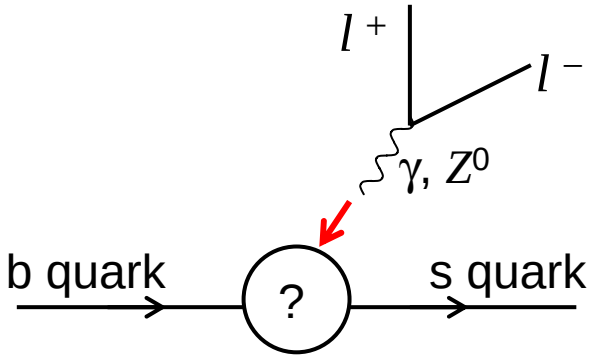
Estimated error in the measurement of time dependent CP violation



Discovery region with 50 ab^{-1}



Search for new flavor mixing



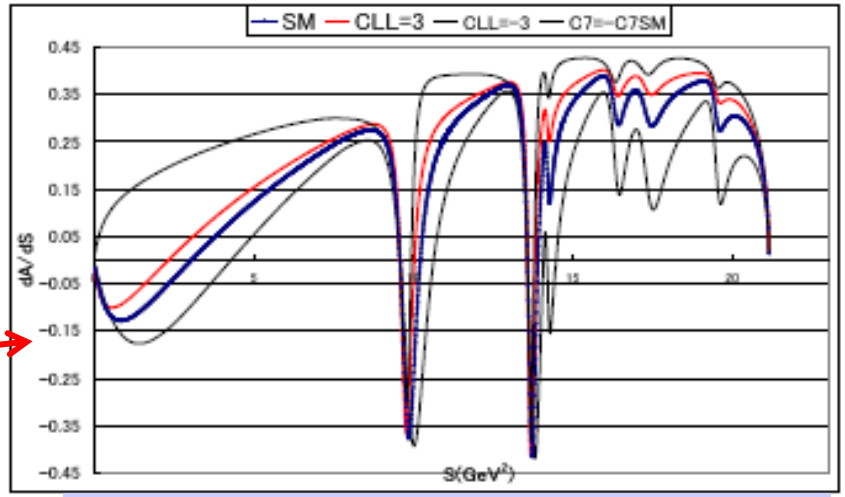
: Probe the flavor changing process with the “EW probe”.

This measurement is especially sensitive to new physics such as SUSY, heavy Higgs and extra dim.

Possible observables:

- Ratio of branching fractions
- Branching fraction
- CP asymmetry
- q^2 distribution
- Isospin asymmetry
- Triple product correlation
- Forward backward asymmetry
- Forward backward CP asymmetry

Theoretical predictions for l^+l^- forward-backward charge asymmetry for SM and SUSY model with various parameter sets.

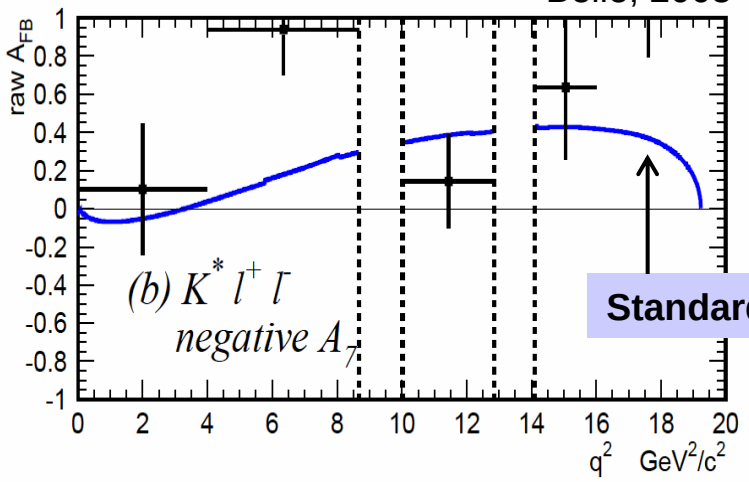


The F/B asymmetry is a consequence of γ-Z^0 interference.

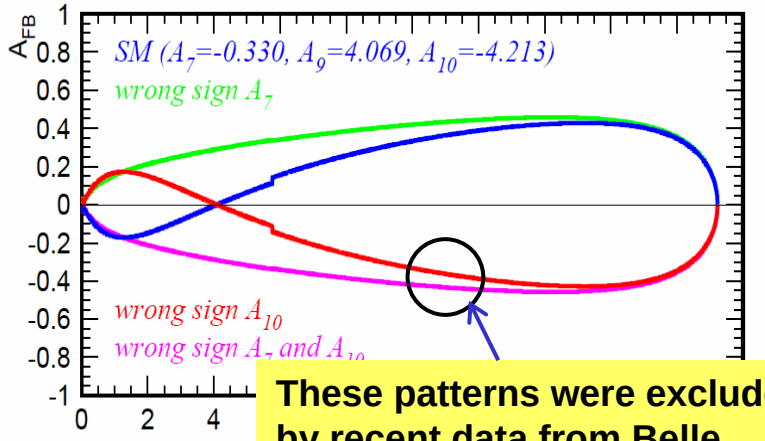
Sensitivity to new flavor mixing

Experimental result with 0.35 ab^{-1}

Belle, 2005

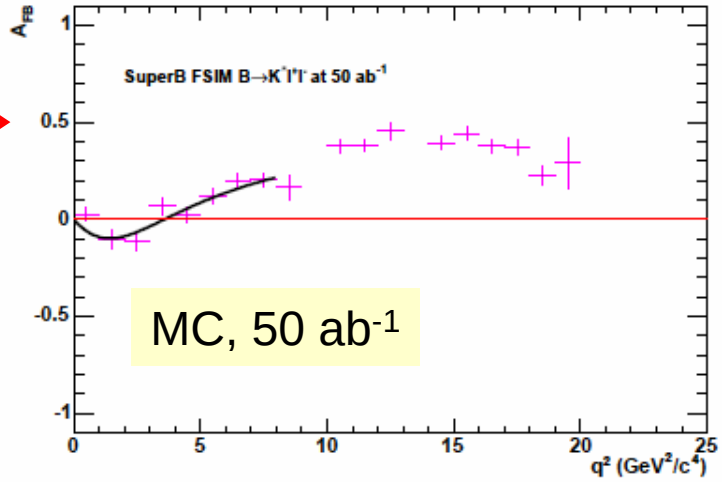


Standard model



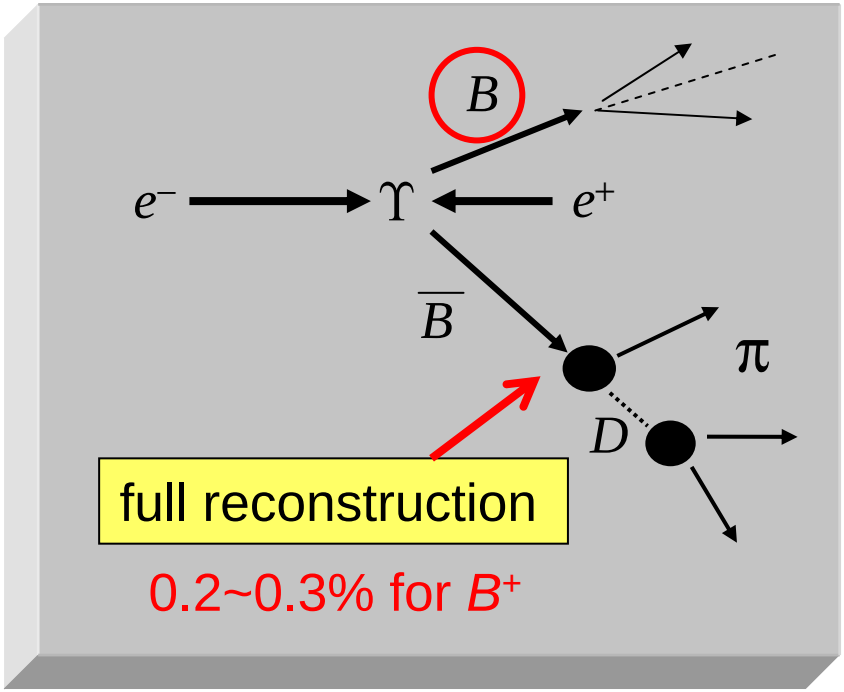
These patterns were excluded by recent data from Belle.

Sensitivity at Super KEKB

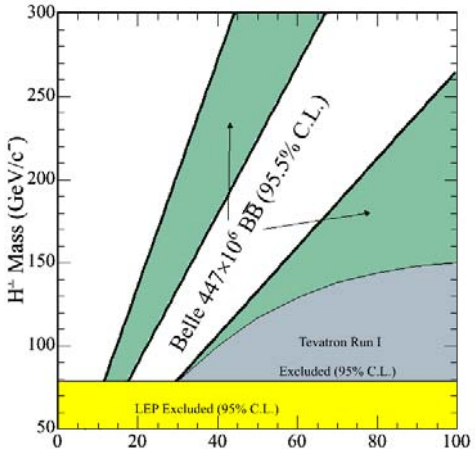


- Zero-crossing q^2 for A_{FB} will be determined with 5% error with 50ab^{-1}.

"*B* meson beam" technique



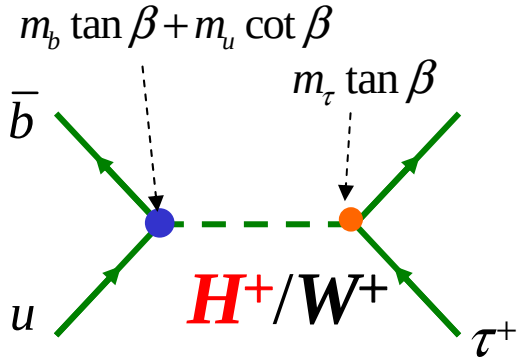
95.5%C.L. exclusion boundaries



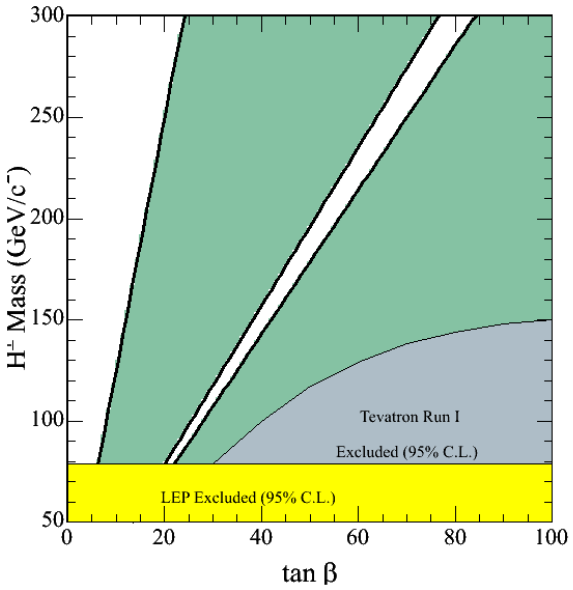
Belle, 2006

Application

$H^{\pm}$ search in $B \to \tau\nu$

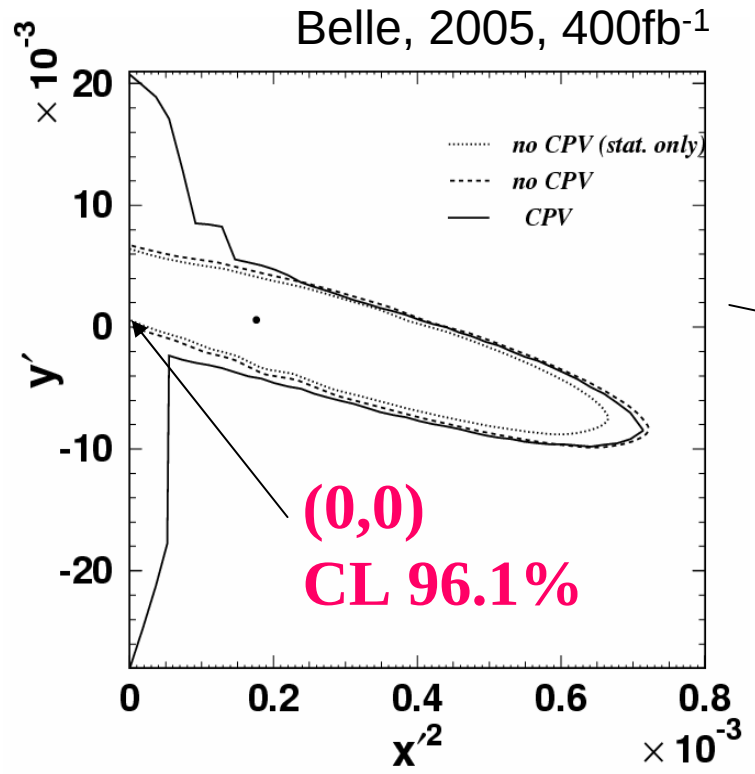


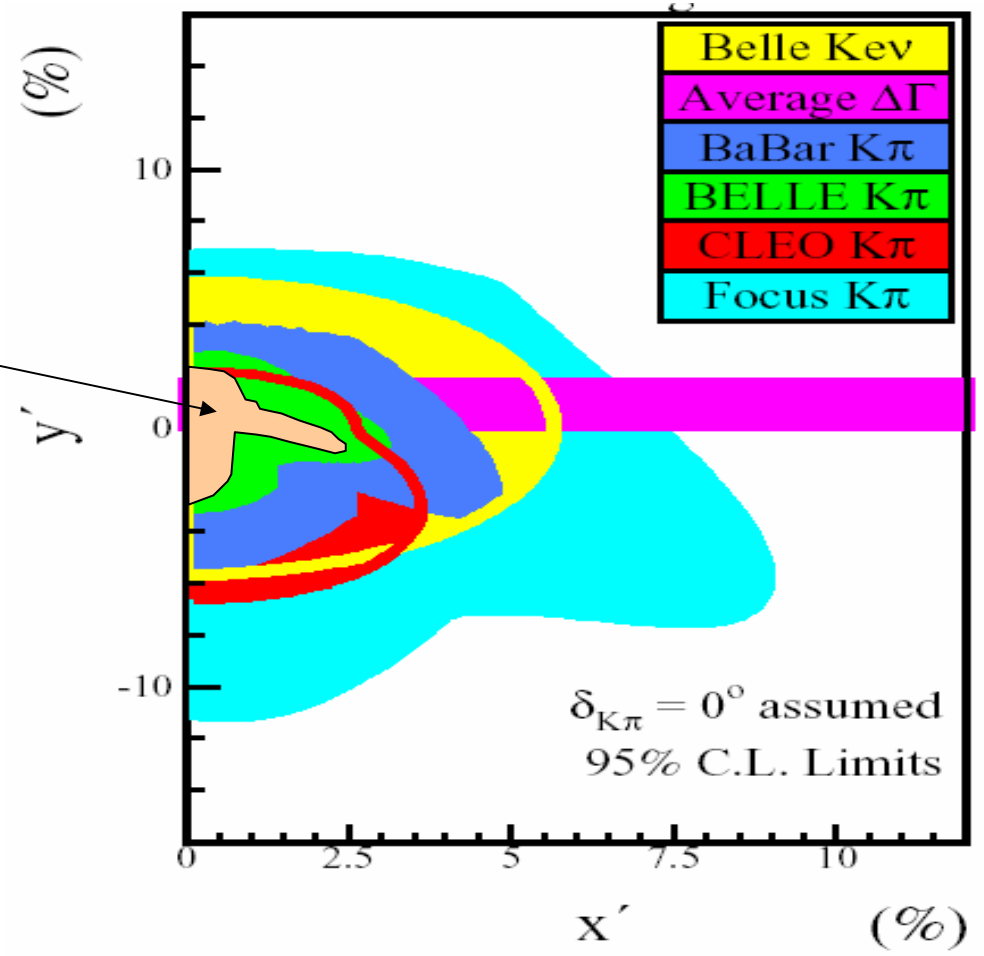
5ab^{-1} assumed



Charm physics at *B* factories

$D^0\overline{D}^0$ mixing may be observed at *B* factories with higher L.

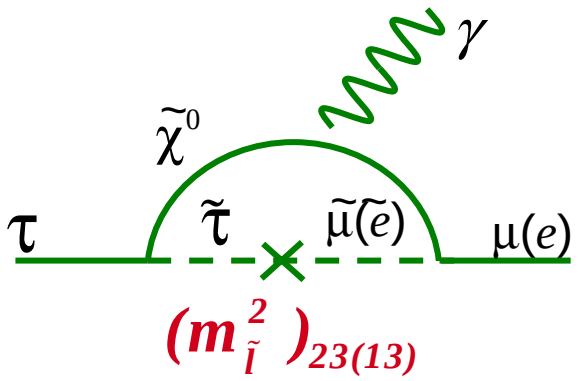




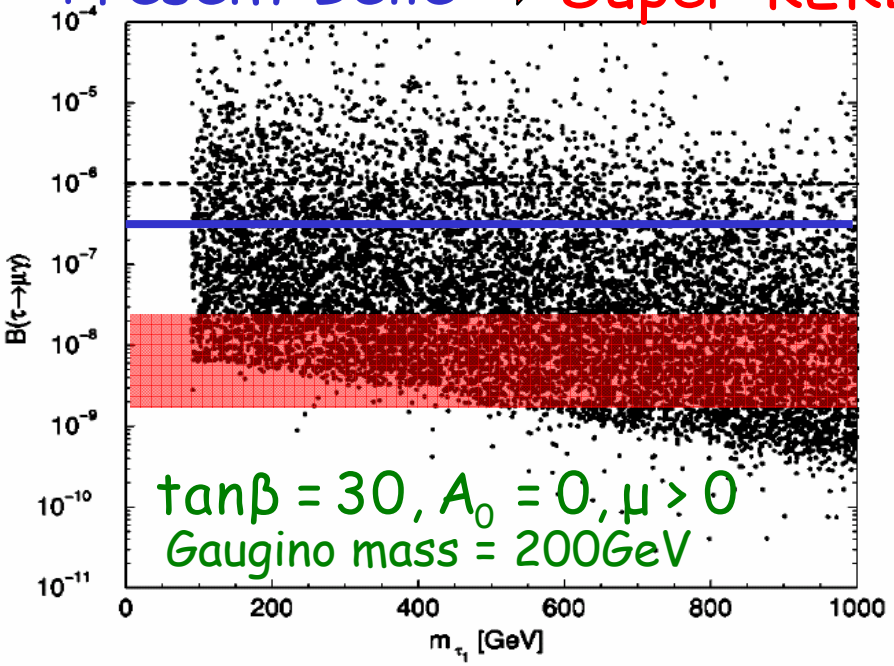
Search for flavor-violating τ decay

- SUSY + Seesaw
  - Flavor violation by ν-Yukawa coupling.
  - Large LFV $Br(\tau \to \mu\gamma) = O(10^{-7\sim9})$

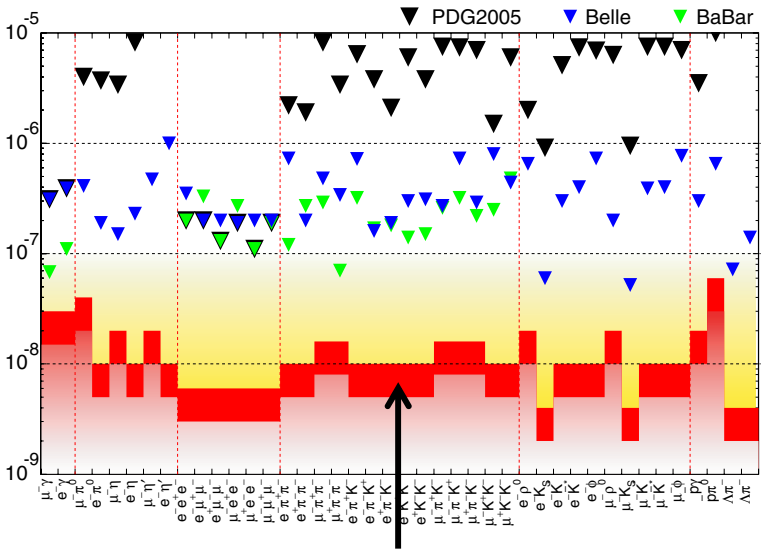
$$BR(\tau \to \mu\gamma) \sim 10^{-6} \times \frac{(m_{\tilde{L}}^2)_{32}}{\overline{m}_{\tilde{L}}^2} \left(\frac{1\ \mathrm{TeV}}{m_{SUSY}}\right)^4 \tan^2\beta$$



Present Belle ➡ Super-KEKB



Expected sensitivity at SuperKEKB



Comparison with LHCb

e^+e^- is advantageous in…	LHCb is advantageous in…
CPV in $B\to\phi K_S$, $\eta' K_S$,…	CPV in $B\to J/\psi K_S$
CPV in $B\to K_S\pi^0\gamma$	Most of B decays not including ν or γ
$B\to K\nu\nu$, $\tau\nu$, $D^{(*)}\tau\nu$	Time dependent measurements of B_S
Inclusive $b\to s\mu\mu$, *see*	$B_{(S,d)}\to\mu\mu$
$\tau\to\mu\gamma$ and other LFV	B_C and bottomed baryons
$D^0\overline{D^0}$ mixing	

These are complementary to each other !!

Why $\int L\,dt = 50\text{ab}^{-1}$ is a goal?

- Most of the interesting measurements will be limited by unavoidable systematics when we reach 50ab^{-1}.

Obs.	δ_{stat} with 50ab^{-1}	δ_{syst} with 50ab^{-1}	Theory err.
$\sin 2\phi_1$	0.004	0.014	~0.01
ϕ_2	1.2º	a few º	
ϕ_3	1.2º	O(1) º	
$\lvert V_{ub}\rvert$	1%	~1%	~5 %
$S_{\phi Ks}$	0.023	0.020	
$A_{\phi Ks}$	0.016	0.018	
$S_{\eta' Ks}$	0.013	0.020	
$A_{\eta' Ks}$	0.009	0.017	
DCPV in $b\to s\gamma$	0.003	0.002	0.003

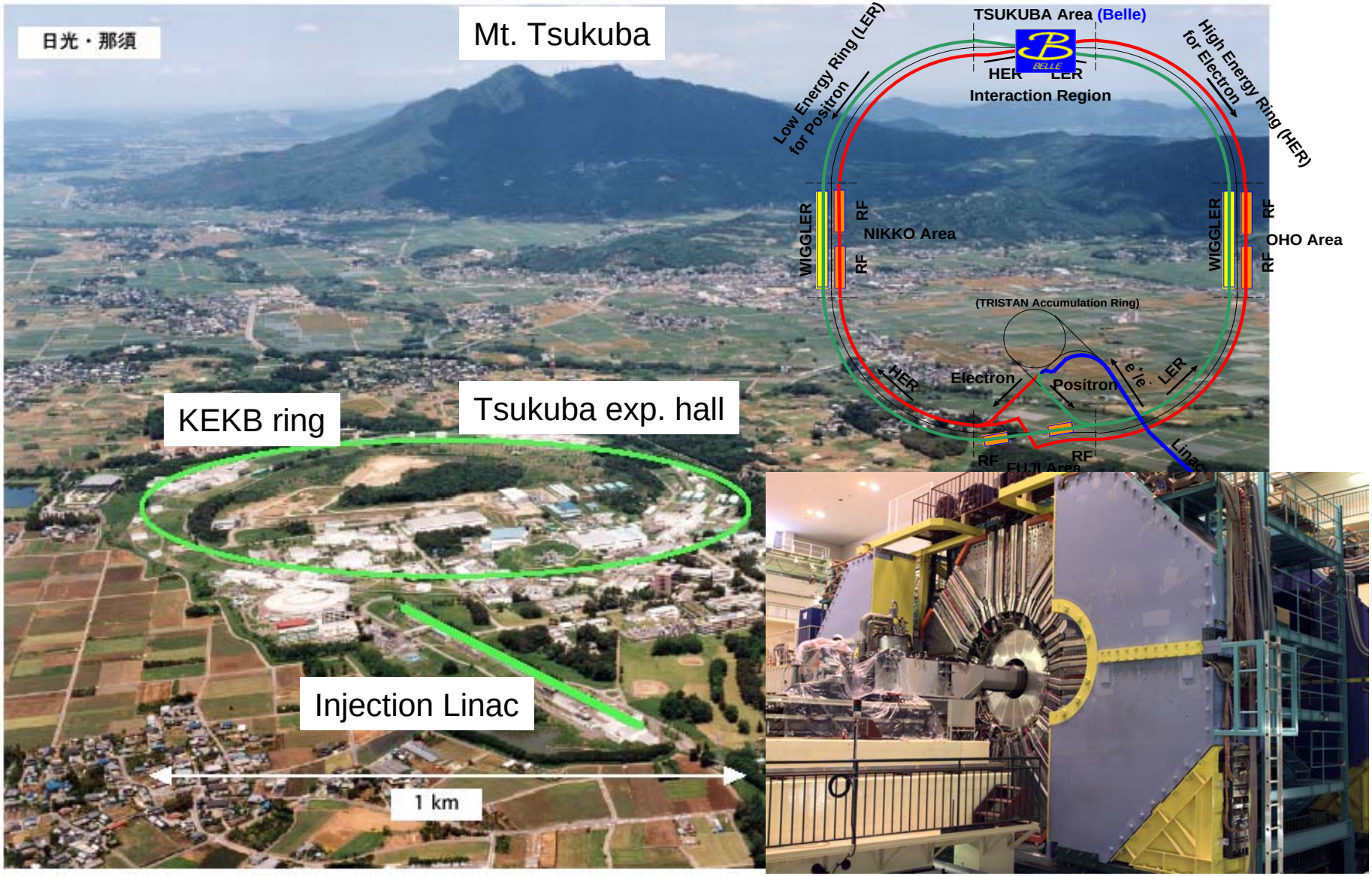
$\int L\,dt = 50\text{ab}^{-1}$

- Takes 250 years with present KEKB
- 8.3 years with $L_{\text{peak}}=4\times10^{35}$:baseline design of SuperKEKB

Great efforts are being made by
the machine physicists at KEK.

- 3.3 years with $L_{\text{peak}}=1\times10^{36}$

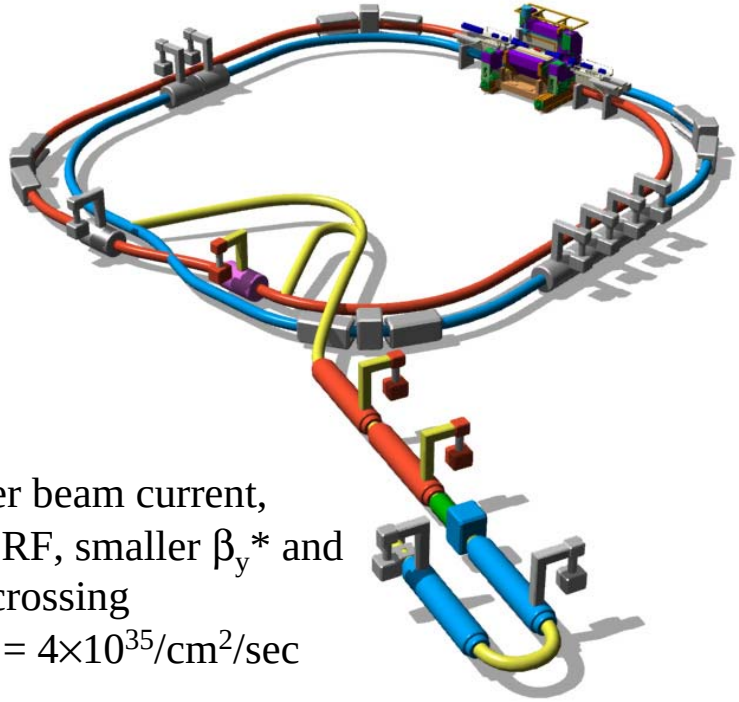
KEKB


日光・那須
Mt. Tsukuba
KEKB ring
Tsukuba exp. hall
Injection Linac
1 km
TSUKUBA Area (Belle)
Low Energy Ring (LER) for Positron
High Energy Ring (HER) for Electron
HER
LER
Interaction Region
WIGGLER
RF
NIKKO Area
OHO Area
(TRISTAN Accumulation Ring)
Electron
Positron
e+/e-
Linac
FUJI Area

SuperKEKB

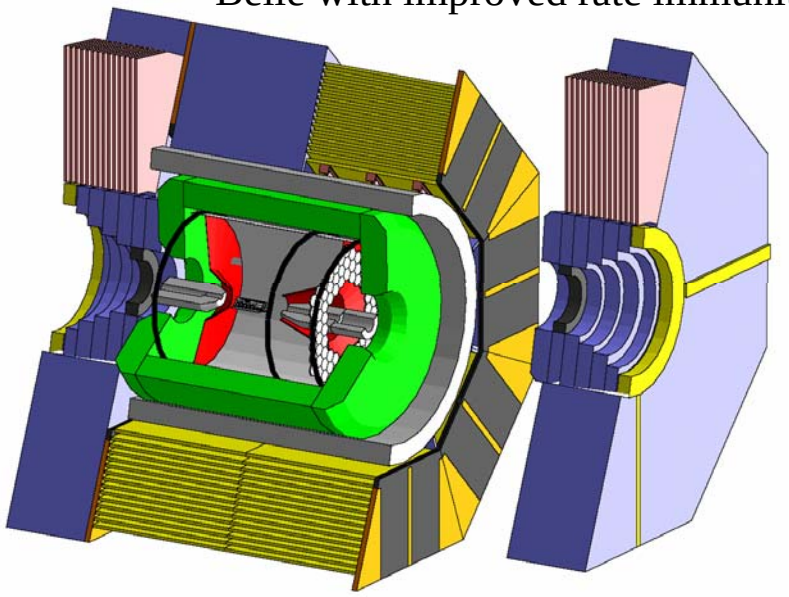
- *Asymmetric energy e^+e^- collider at $E_{CM}=m(\Upsilon(4S))$ to be realized by upgrading the existing KEKB collider.*
- *Super-high luminosity $\cong 4\times10^{35}$/cm^2/sec $\rightarrow 5\times10^9$ BB per yr.*

  $\rightarrow 4\times10^9$ $\tau^+\tau^-$ per yr.



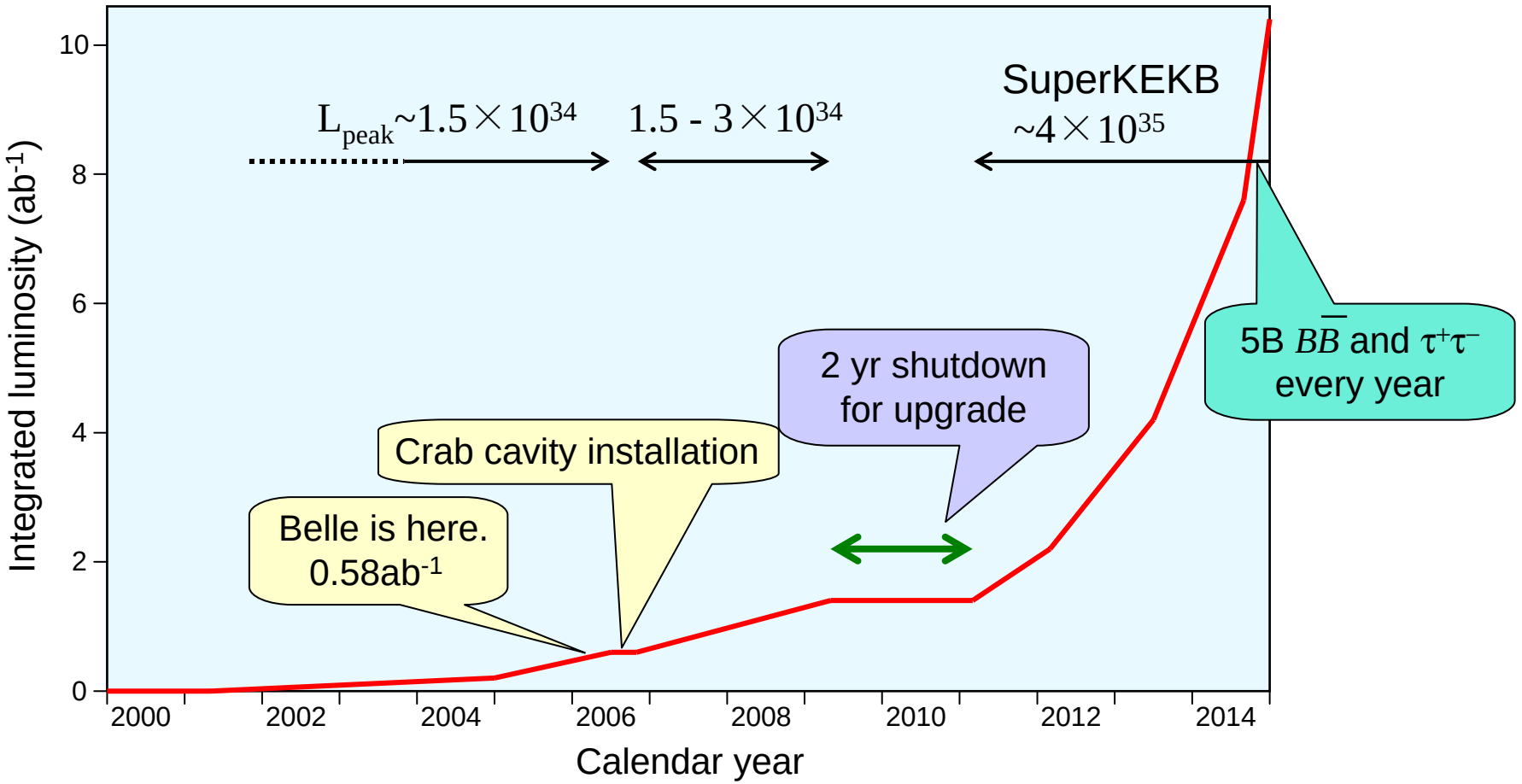
Higher beam current,
more RF, smaller β_y* and
crab crossing
$\rightarrow$ L = 4×10^{35}/cm^2/sec

Belle with improved rate immunity

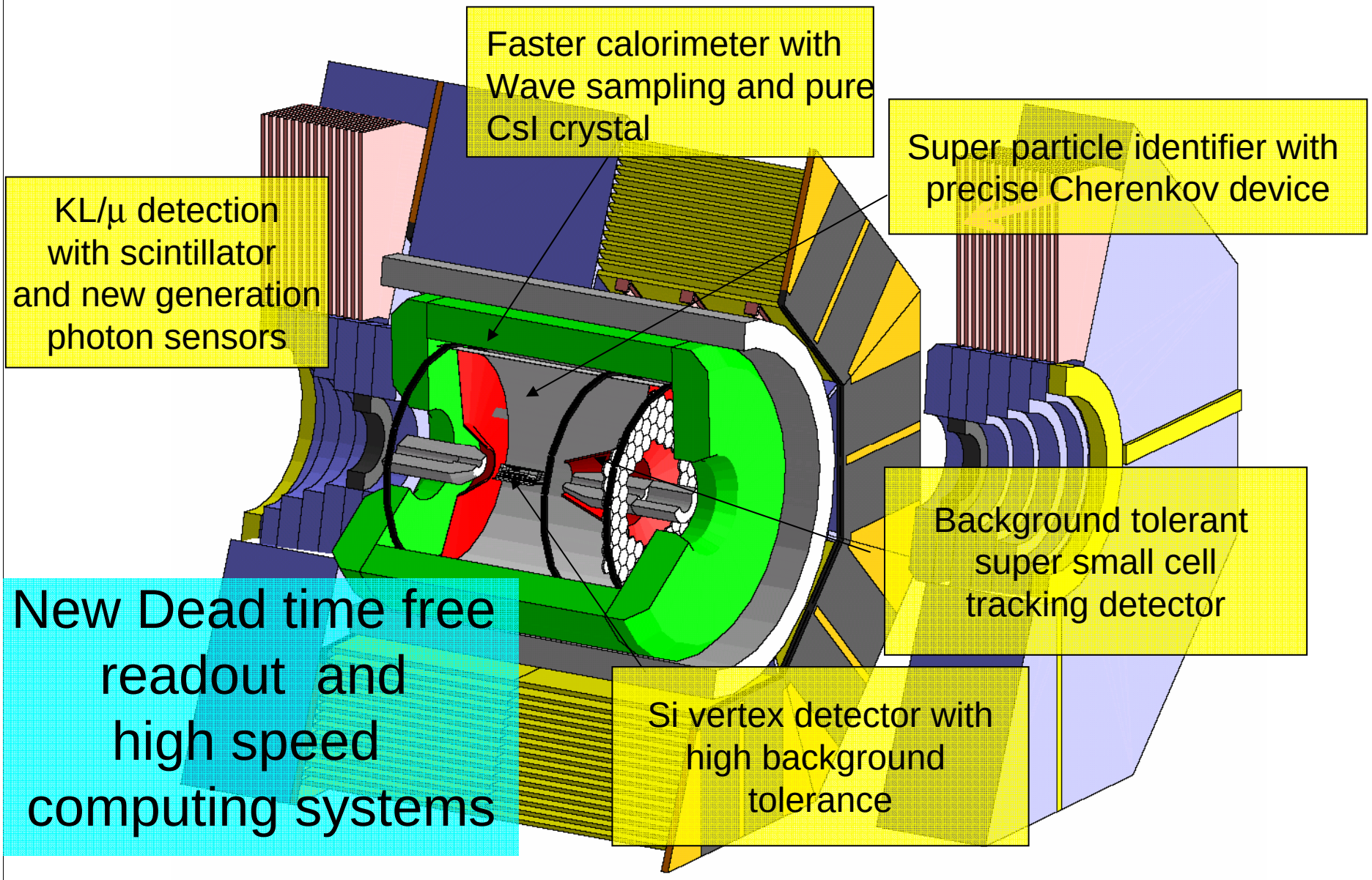


http://belle.kek.jp/superb/loi

Proposed schedule

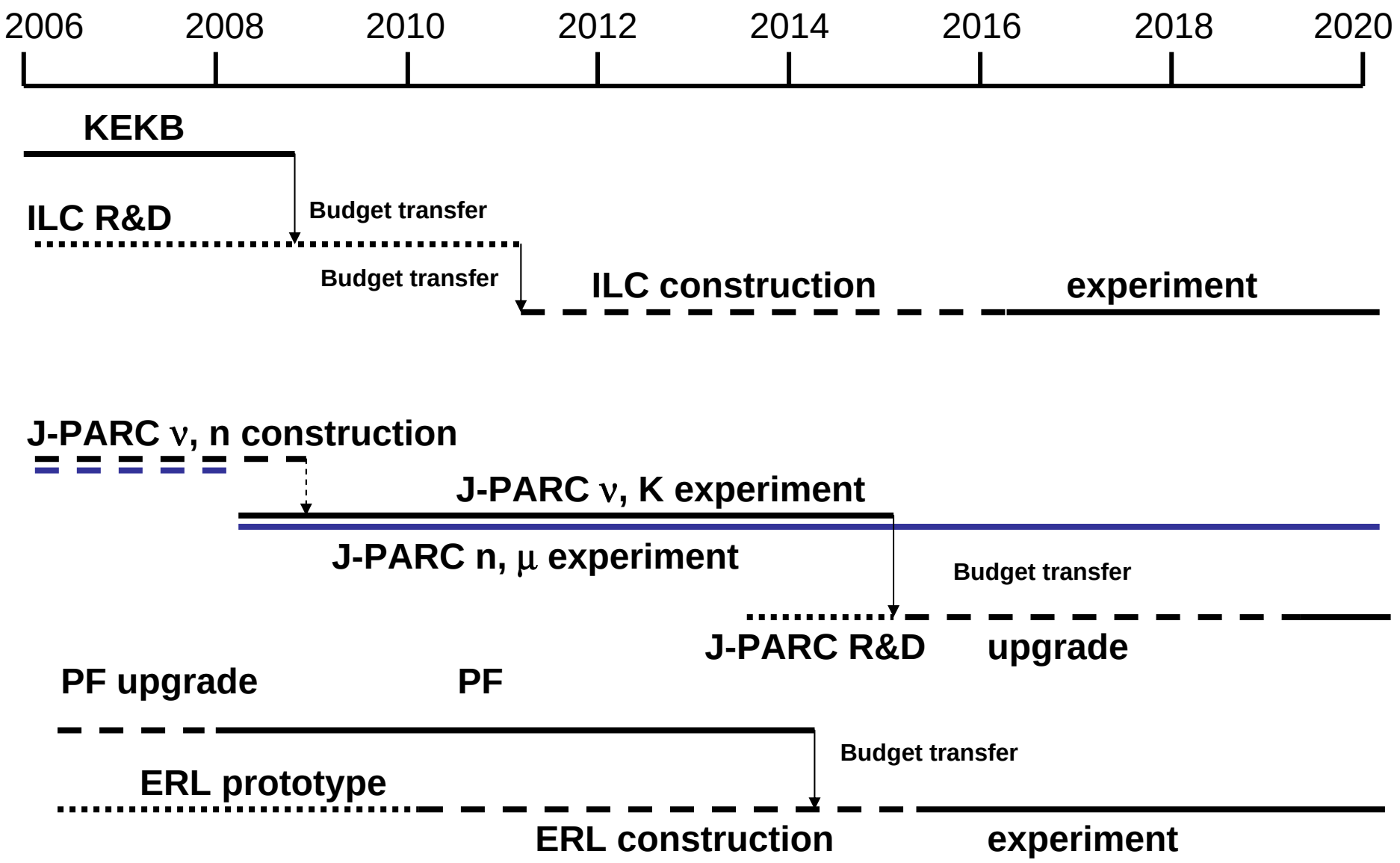


Super Belle


Faster calorimeter with Wave sampling and pure CsI crystal
Super particle identifier with precise Cherenkov device
KL/μ detection with scintillator and new generation photon sensors
Background tolerant super small cell tracking detector
Si vertex detector with high background tolerance
New Dead time free readout and high speed computing systems

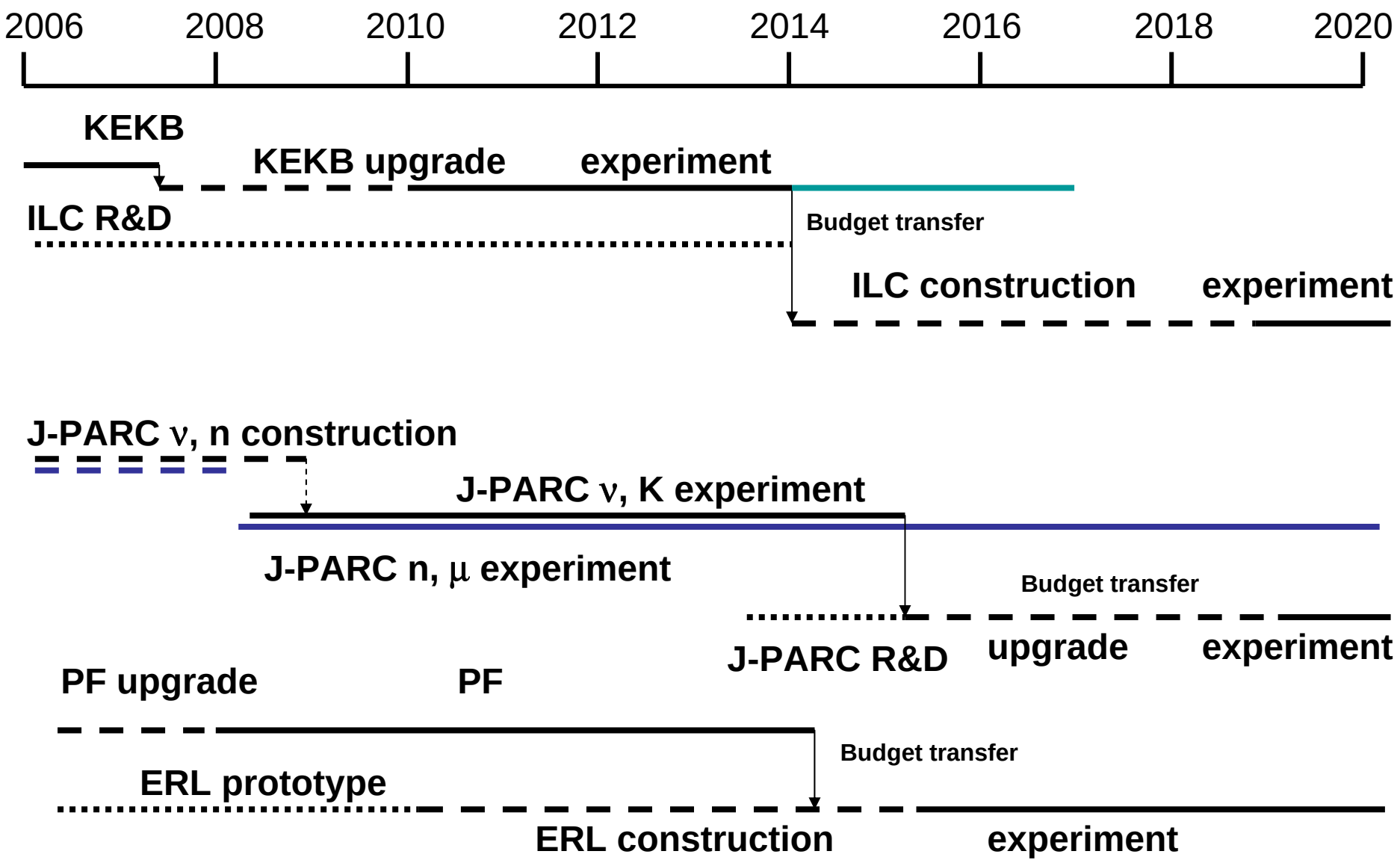
Situation at KEK

- Next three slides are from the report of “Future vision committee” lead by the previous KEK director, Yoji Totsuka, given to the new director, Atsuto Suzuki, WITHOUT giving any constraint to the new management.



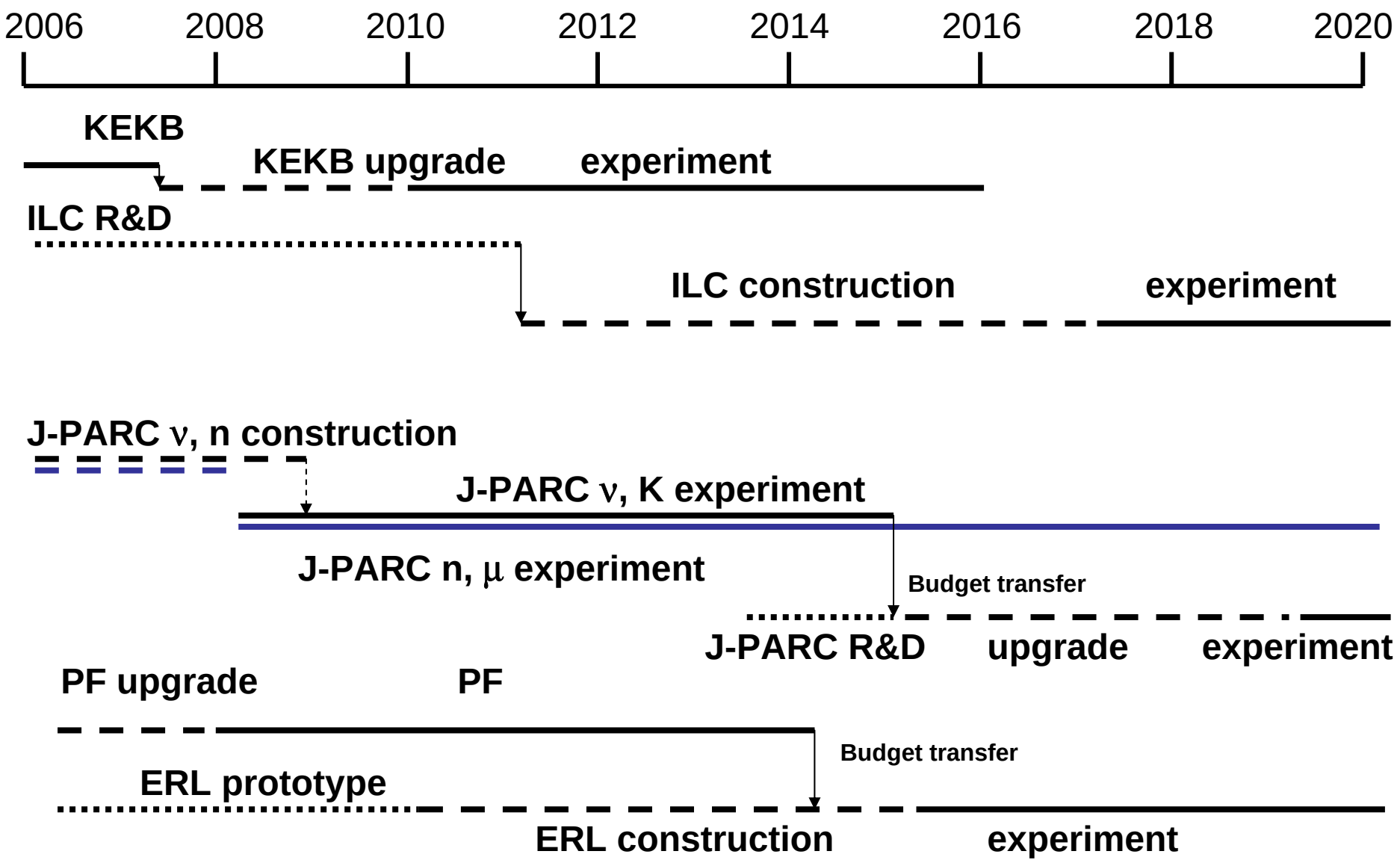
Scenario Version 1

By previous KEK management



Scenario Version 2

By previous KEK management



Scenario Version 3

By previous KEK management

LCPAC recommendation

- LCPAC is a KEK's advisory panel that gives recommendation on the e^+e^- collider program at KEK.
- 2005 report says;

> The main objective of SuperBelle is to elucidate the flavor structure of anticipated new physics at or beyond the TeV scale. We find the presented scientific goal exciting.
>
> The Committee recommends to continue the accelerator and the detector R&D so that SuperKEKB can be proposed for construction when the time is ripe.

Internationalization

- “KEK + in-kind contribution from others” is a favorable scenario.
  - KEK cannot afford to pay for all, because it will also support J-PARC and ILC R&D.
  - Better chance to get early approval by the Japanese Government.
- We are open to any proposal.
- A possible way: form an international steering group of Super B factory without having a specific site or technology selected.
  - Have both SuperKEKB and Linear Super B (and others, if any) in the scope.
  - Make Super B factory more popular in the world-wide HEP community.
  - Submit joint proposals to the possible host labs.

BNM2006 - Mozilla Firefox

ファイル(F) 編集(E) 表示(V) 移動(G) ブックマーク(B) ツール(T) ヘルプ(H)

http://www-conf.kek.jp/bnm/2006/index.html 移動

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Top Bulletin Registration Program Proceedings KEK

Sep. 13-14, 2006
KEK, Tsukuba, Japan

Topics
Upsilon(5s) and Other Energies
New Ideas on Upsilon(4s)
SuperKEKB Physics
New Detectors

Local Organizing Committee
S. Hashimoto (KEK),
M. Hazumi (KEK, Chair),
H. Ishino (TIT),
K. Kinoshita (Cincinnati),
Y. Okada (KEK),
O. Tajima (KEK)

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Summary

- KEKB/Belle has been running very successfully, and brought important scientific achievements together with BaBar.
- Next generation e^+e^- *B* factory with L>>10^{35} will be very useful to study the new sources of flavor mixing and CP violation.
- SuperKEKB upgrade has been proposed
  - Why? – Search for new sources of flavor mixing and CP violation
  - How? – Increase N_B, decrease β_y^*, and crab crossing: $L=4\times10^{35}/cm^2/s$
  - What? – New beam pipe, crab cavity, new injector with damping ring. Belle will also be upgraded assuming DC is usable.
  - Who? – KEKB/Belle is ready to serve as a core of the project, but it is open.
  - Where? – Upgrade existing KEKB.
  - When? – JFY2009 and 2010
  - How much? – up to US$400M, depending on what to be upgraded.
- Internationalization will be necessary for any Super B Factory to be realized.