Super B Factories

July 8, 2006

Physics at LHC
Krakow

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KEK

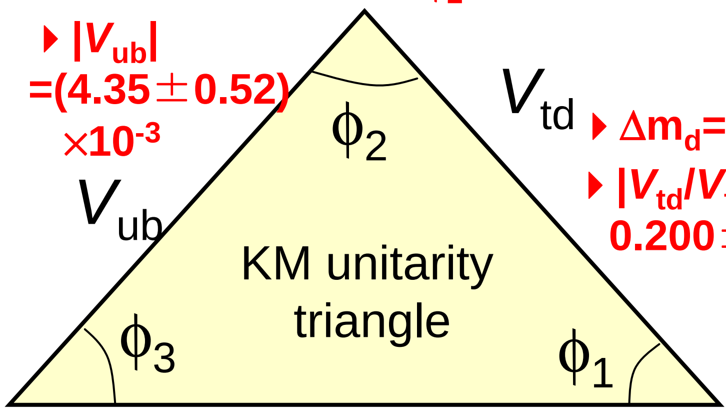
Outline

- Introduction
- Achievements of the *B* factories and the next step
- Physics at SuperB
- Two Super B factory proposals
  - SuperKEKB
  - ILC inspired SuperB
- Summary

Achievements of the *B* Factories

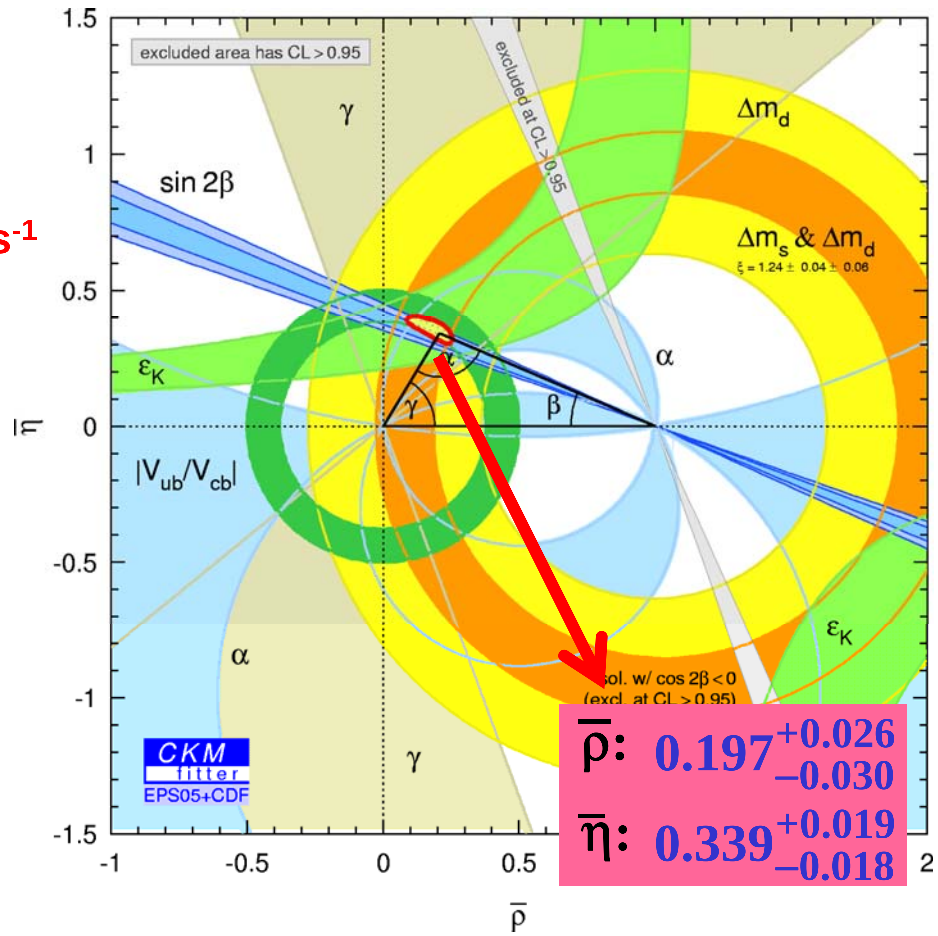
Quantitative confirmation of the KM model

- $75^\circ < \phi_2 < 113^\circ$
- $|V_{ub}| = (4.35 \pm 0.52) \times 10^{-3}$



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

(Belle, 2005)

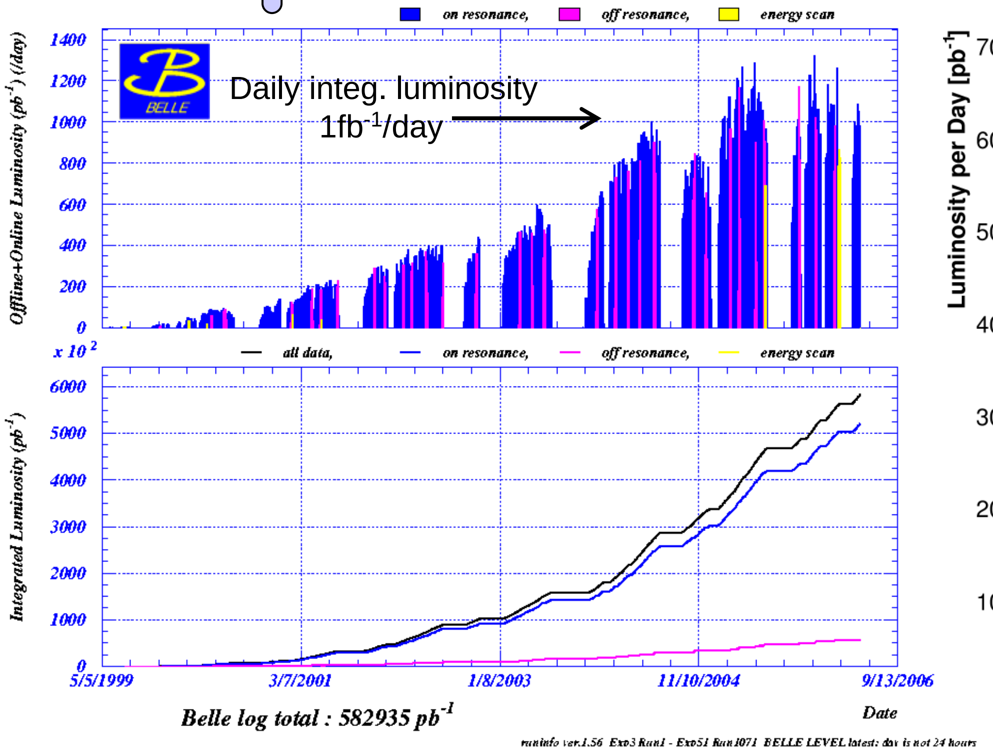


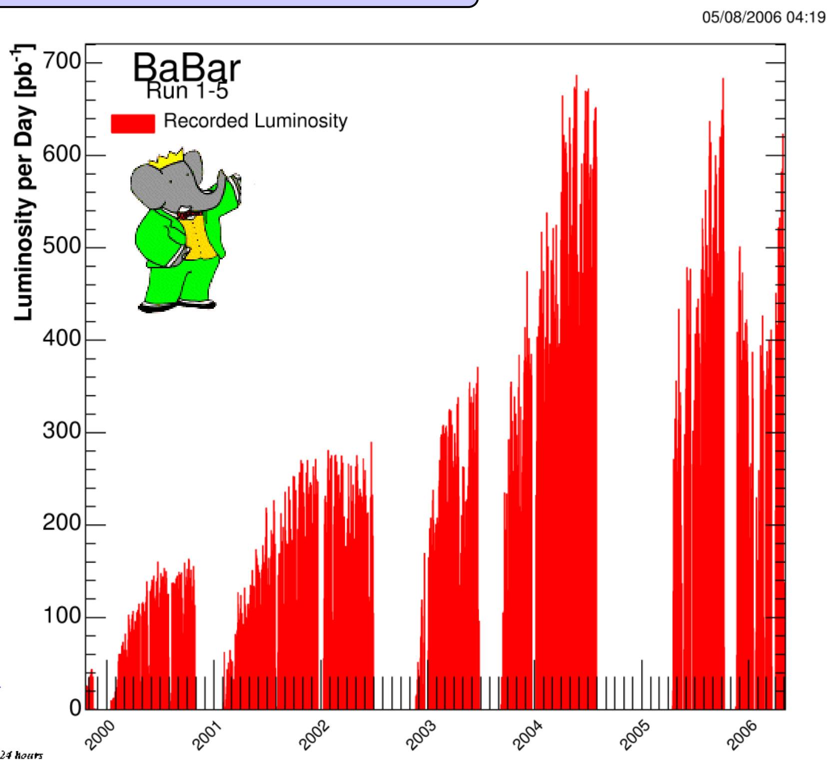
$\bar{\rho}$: $0.197^{+0.026}_{-0.030}$

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

Another important achievement

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





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

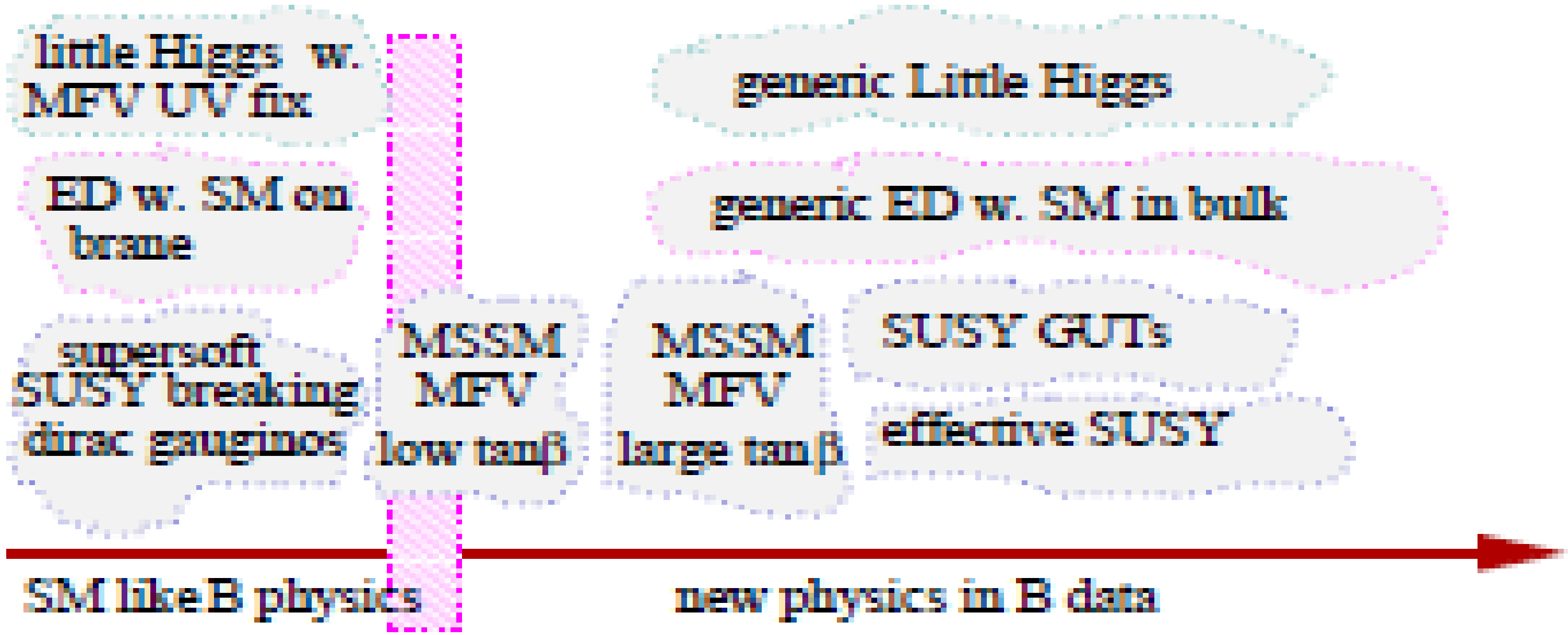
What is next with flavour physics?

- If new physics at O(1)TeV…
  - It is natural to assume that the effects are seen in *B*/*D*/τ 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

New resonances, $D^0\overline{D}^0$ mixing…

Super-high statistics measurements:

α_S, $\sin^2\theta_W$, etc.

Precision test of KM scheme

50 ab^{-1}

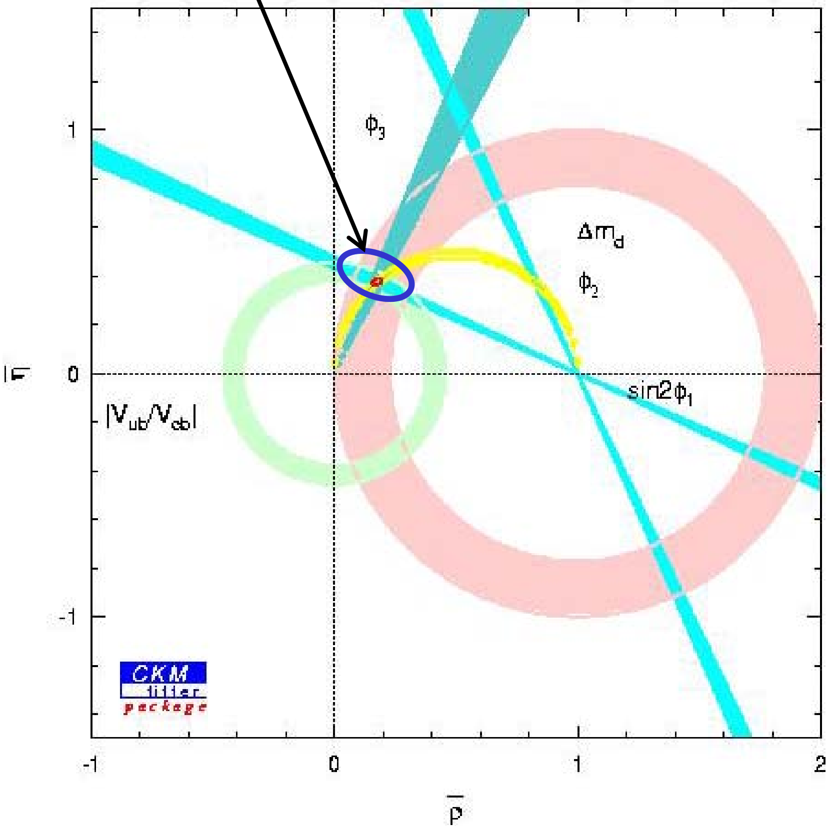
$$\Delta \sin 2\phi_1 = 0.014$$

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

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

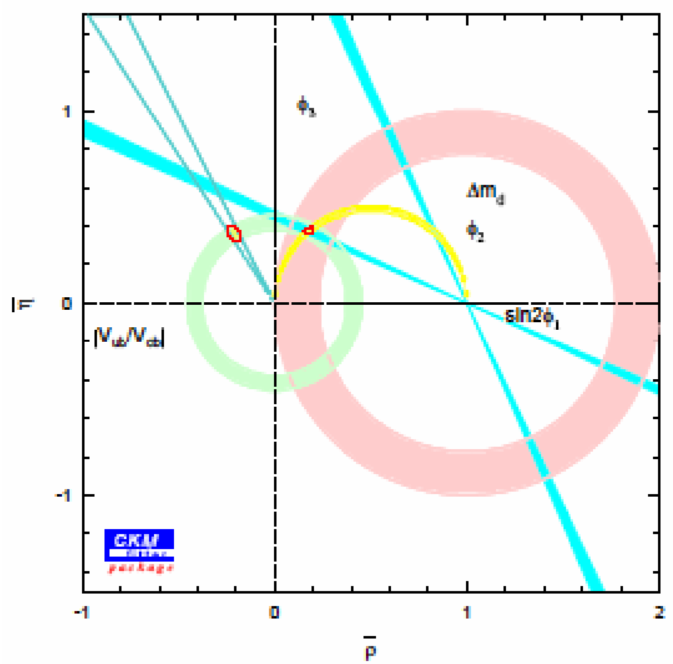
$$\Delta \phi_3 = 1.2^\circ$$

Result with 0.3fb^{-1}

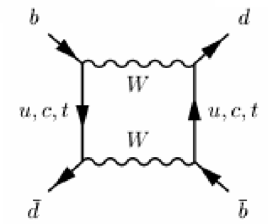


or

If tree-level and *b*→*d* mixing processes give inconsistent results,



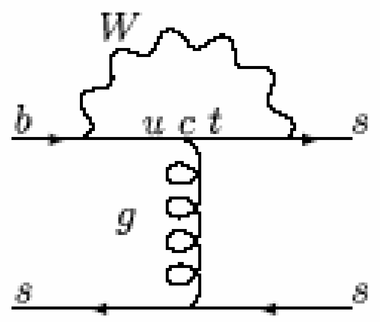
…indicates something new in



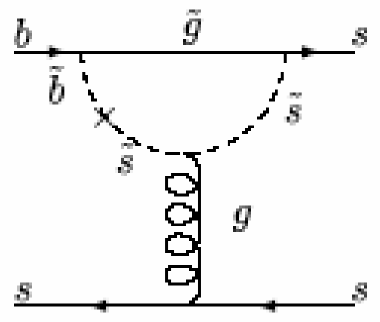
Search for new CP phases

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.

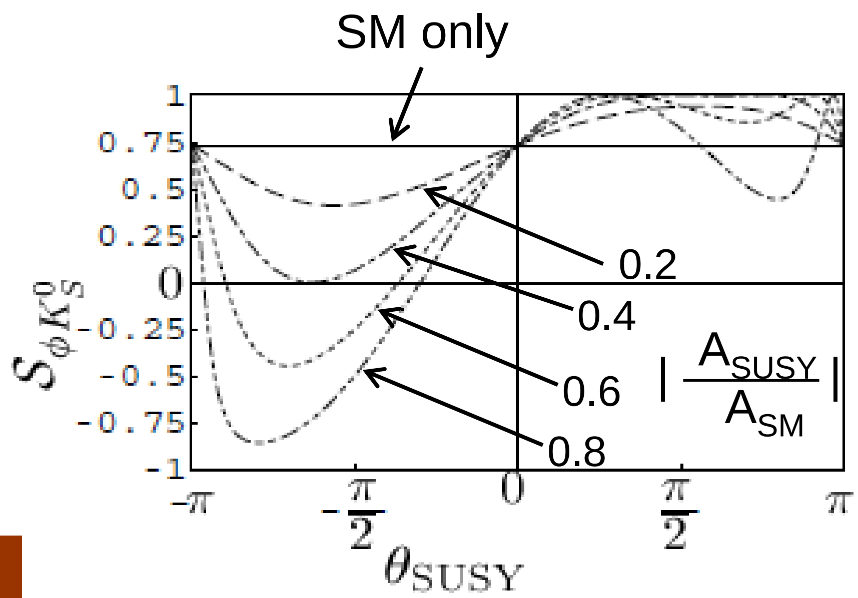


SM



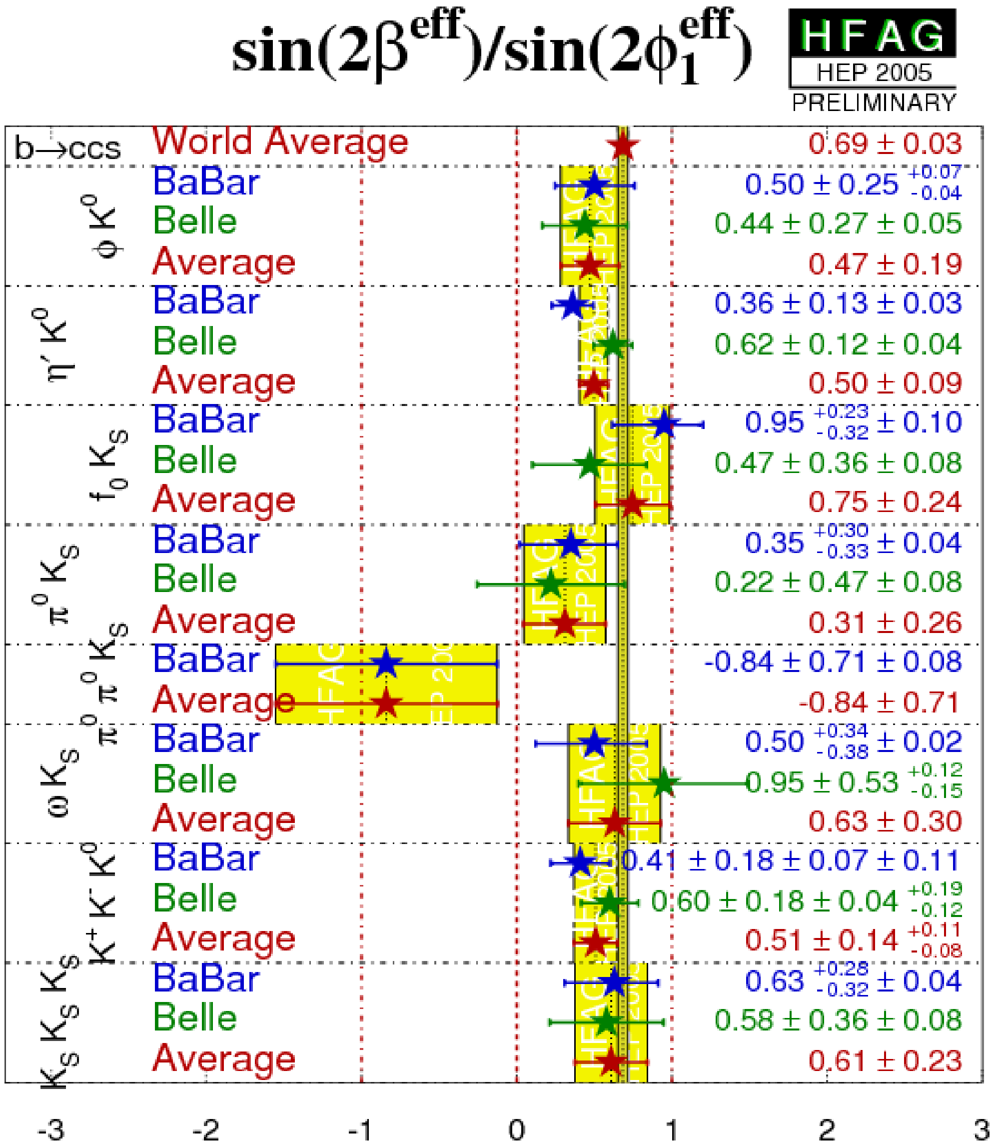
SUSY contribution

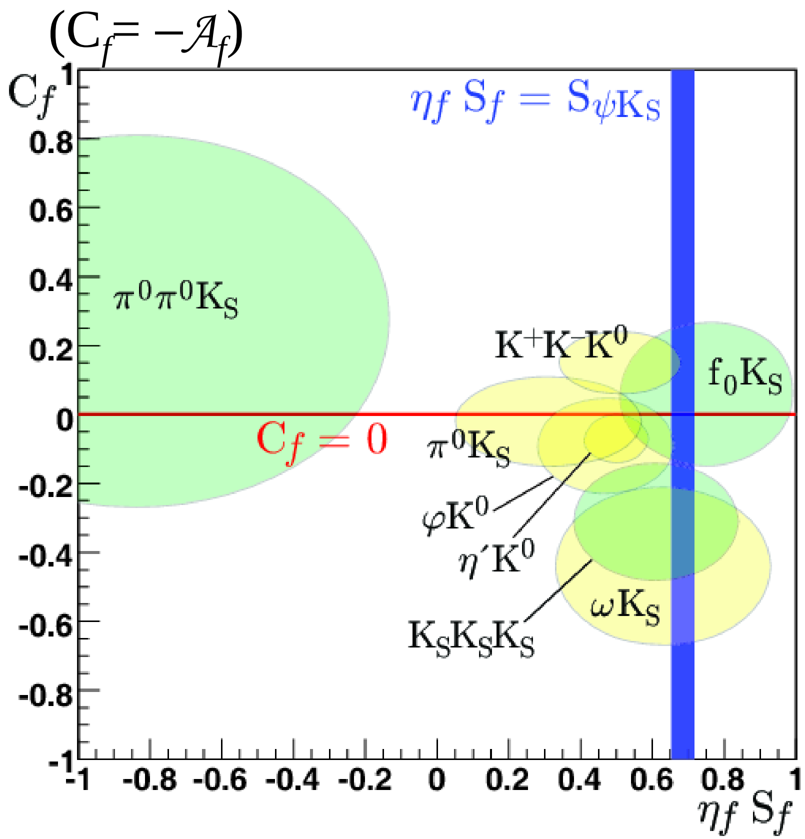
In general, if SUSY is present, the *s*-quark mixing matrix contains complex phases just as in the Kobayashi-Maskawa matrix.



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

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

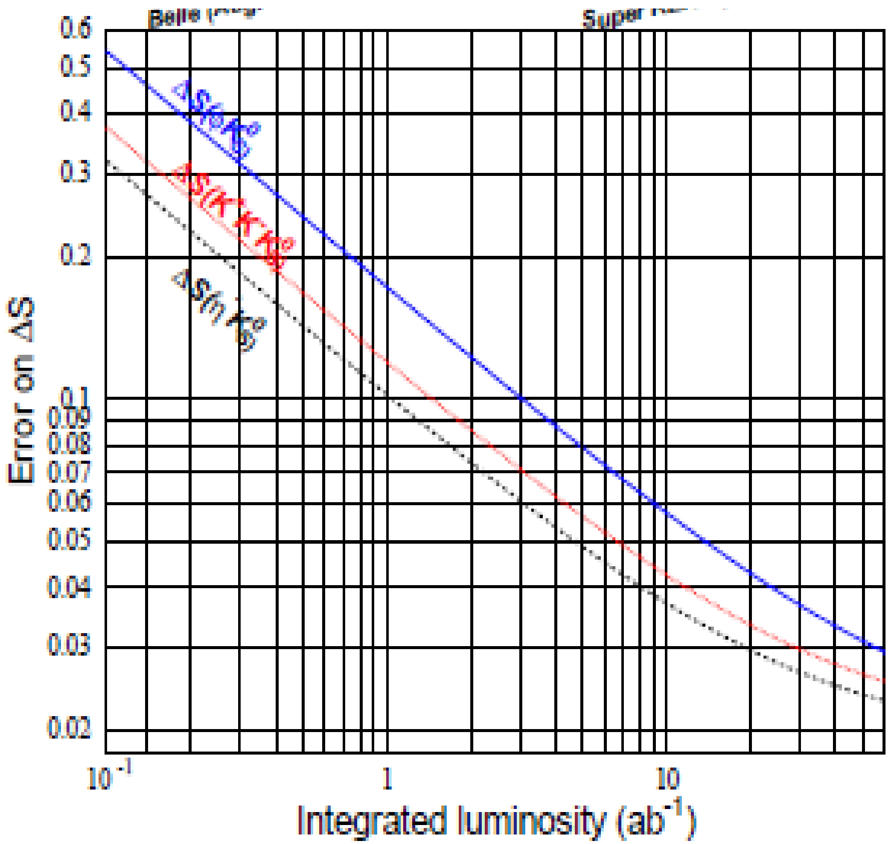




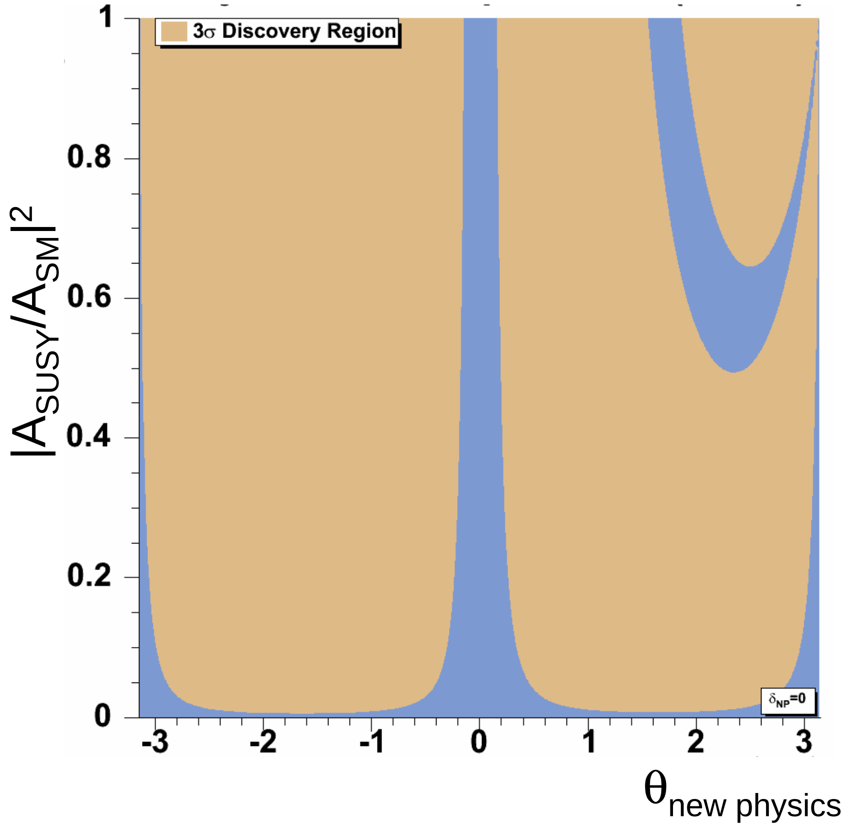
Naïve average
$\sin 2\phi_1^{eff} = 0.5 \pm 0.09$
(2.6σ from $\sin 2\phi_1$)

Sensitivity to new CP phases

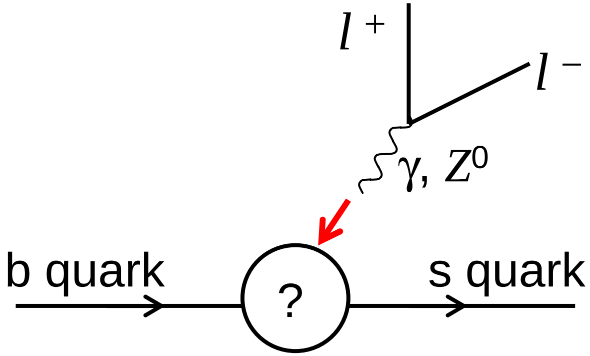
Estimated error in the measurement of time dependent CP violation



Discovery region with 50 ab^{-1}



Search for new flavor mixing



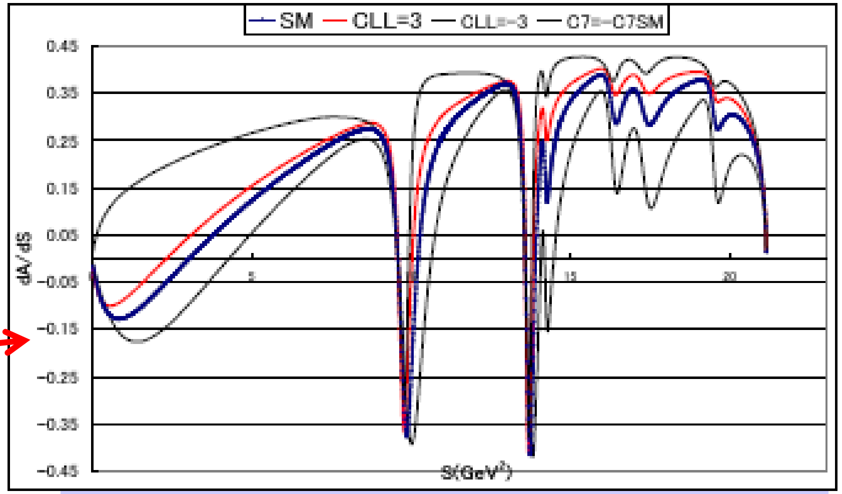
: Probe the flavor changing process with the “EW probe”.

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

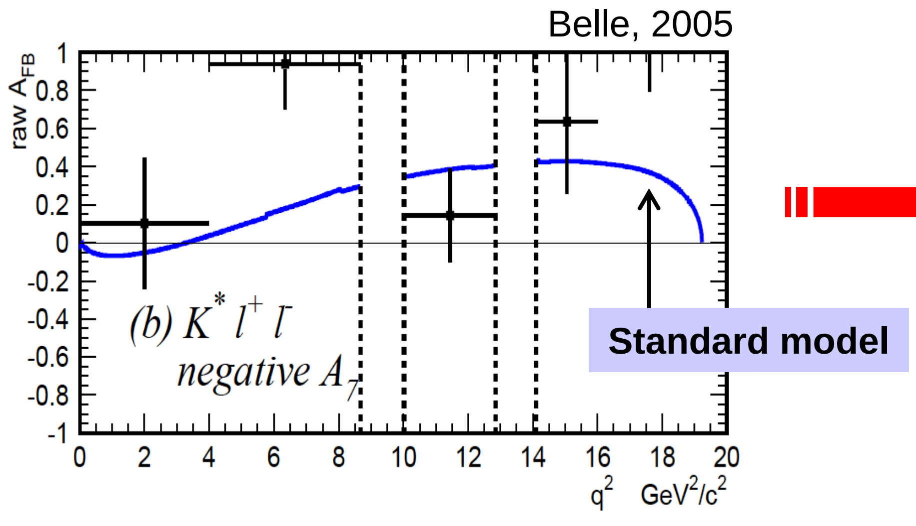
Theoretical predictions for l^+l^- forward-backward charge asymmetry for SM and SUSY model with various parameter sets.

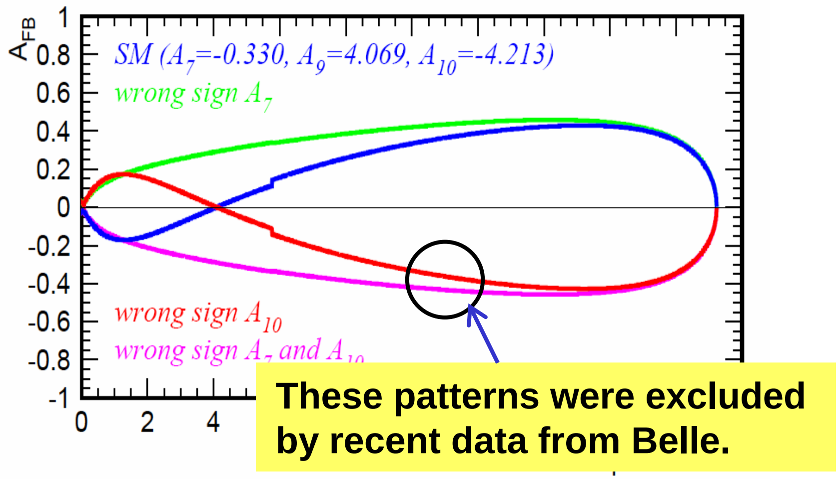


The F/B asymmetry is a consequence of γ-Z^0 interference.

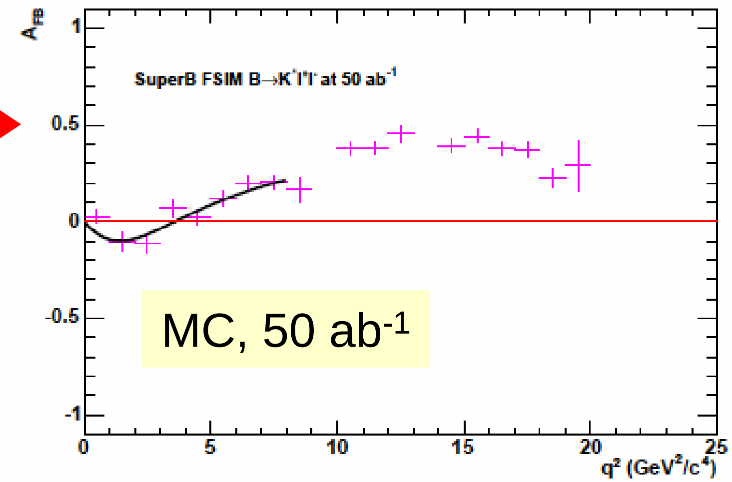
Sensitivity to new flavour mixing

Experimental result with 0.35 ab^{-1}



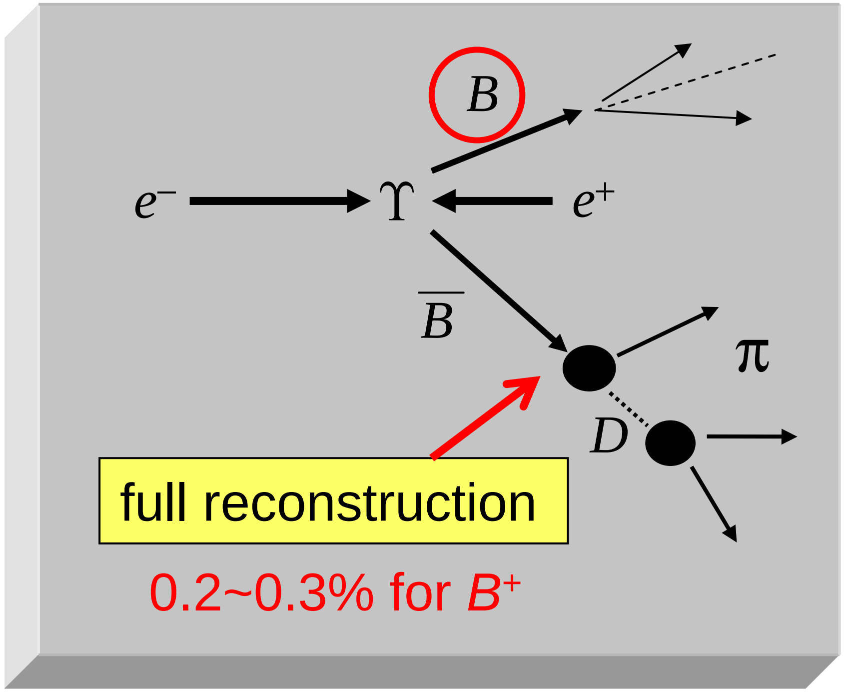


Sensitivity at Super KEKB

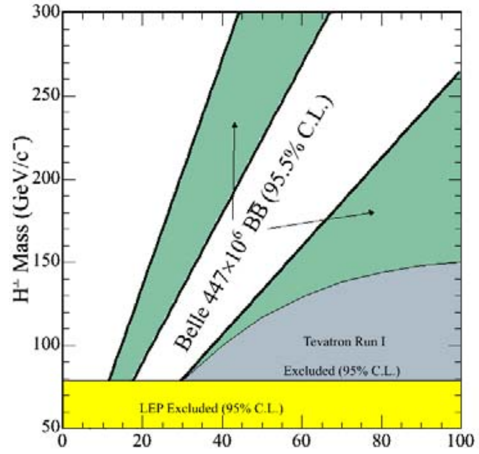


- Zero-crossing q^2 for A_{FB} will be determined with 5% error with 50ab^{-1}.

"*B* meson beam" technique



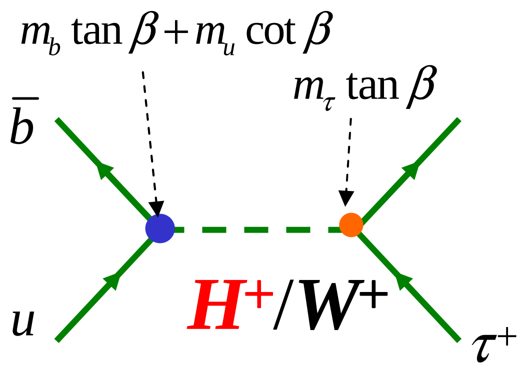
95.5%C.L. exclusion boundaries



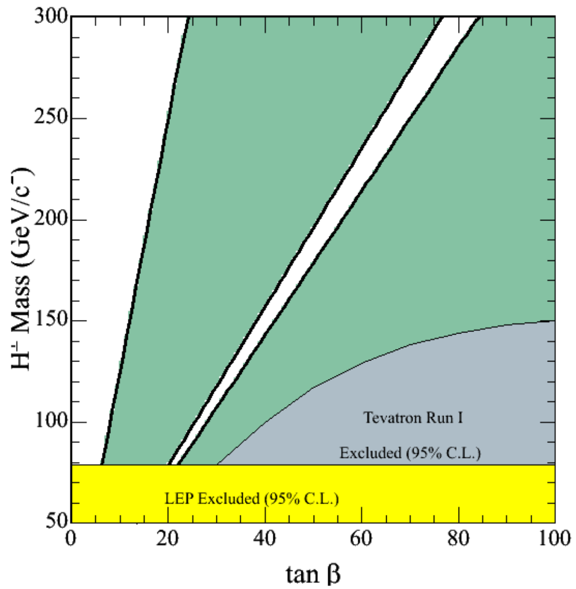
Belle, 2006

Application

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

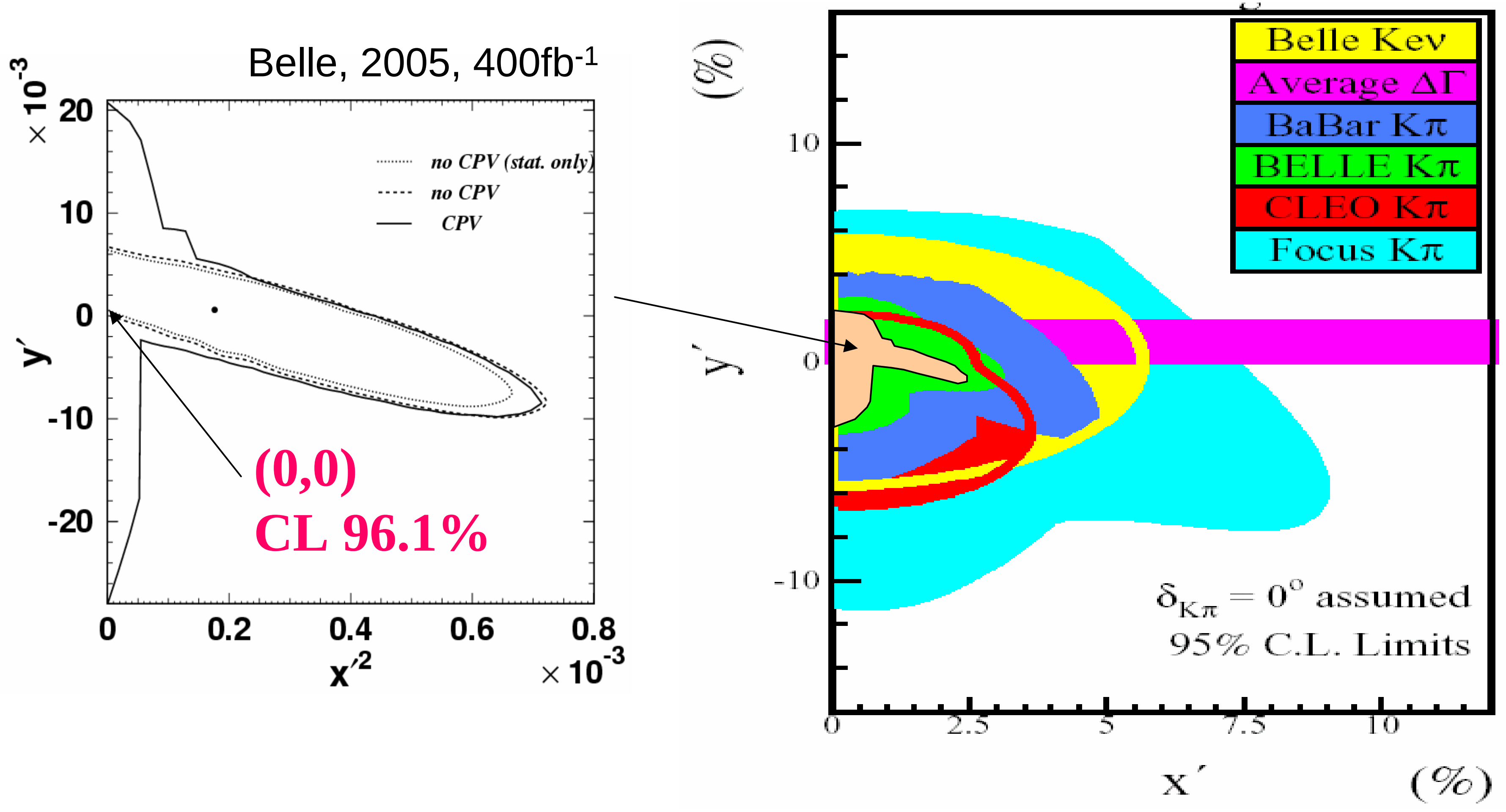


5ab^{-1}
assumed



Charm physics at *B* factories

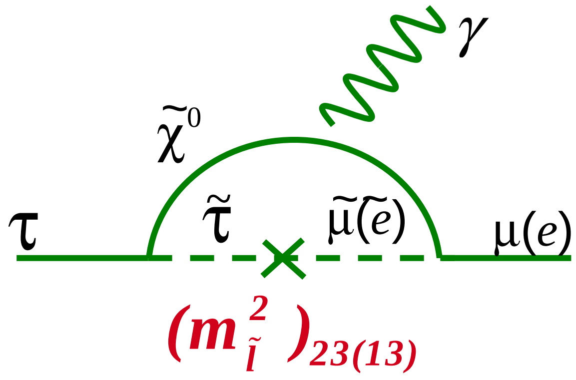
$D^0\overline{D^0}$ mixing may be observed at *B* factories with higher L.



Search for flavor-violating τ decay

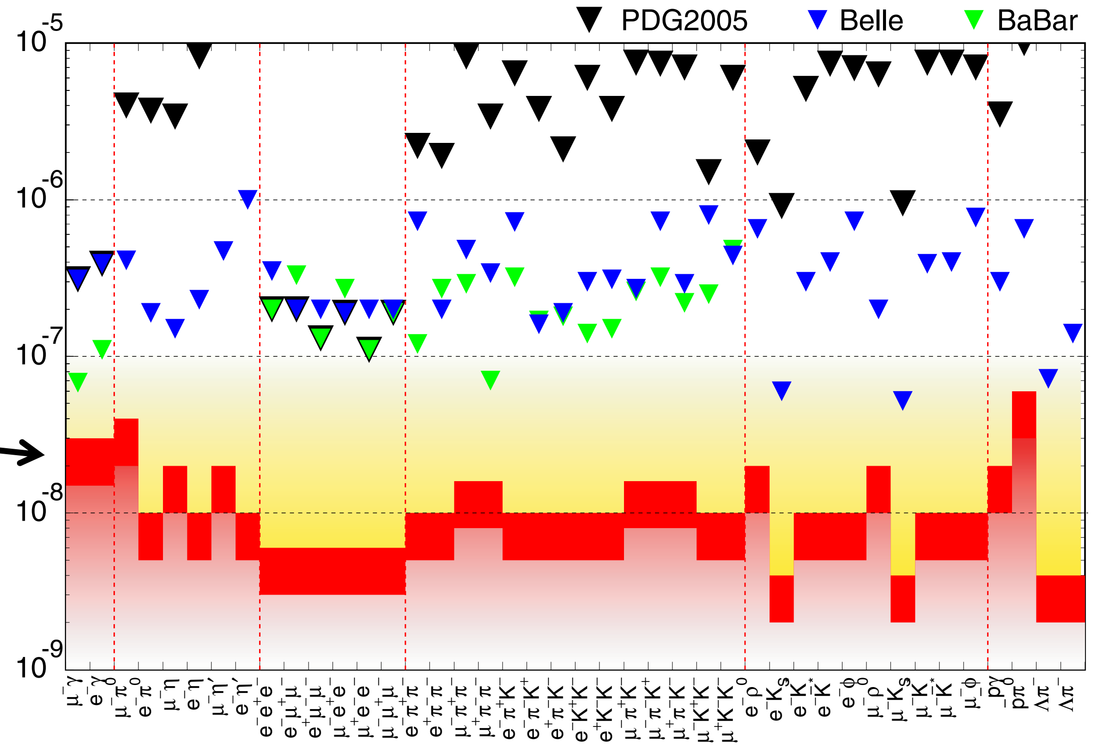
- SUSY + Seesaw
  - Flavor violation by ν-Yukawa coupling.
  - Large LFV $Br(\tau\rightarrow\mu\gamma)=O(10^{-7\sim9})$

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



Expected sensitivity
at SuperB

SuperB
$10ab^{-1}$



Comparison with LHCb/ATLAS/CMS

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	

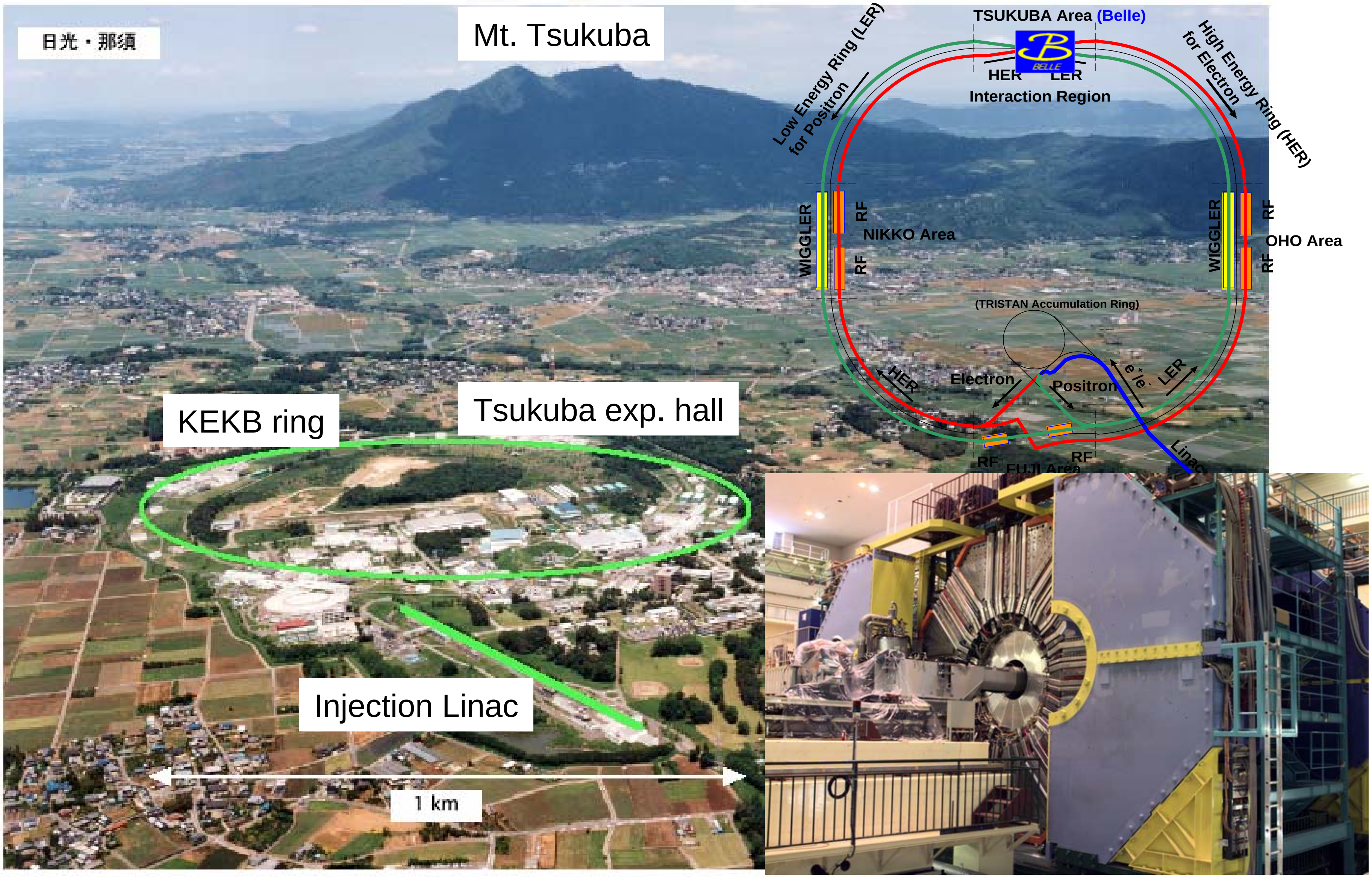
These are complementary to each other !!

Goal: $\int L\, dt$ = 50-100 ab^{-1}

- Most of the interesting measurements will be limited by unavoidable systematics when we reach 50-100 ab^{-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	1.2^o	a few ^{o}	
ϕ_3	1.2^o	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

KEKB

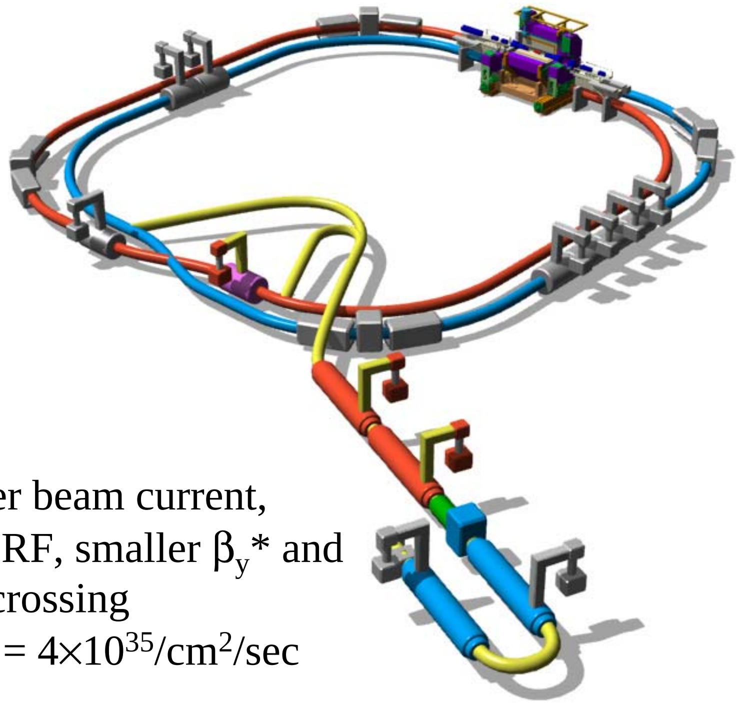


日光・那須
Mt. Tsukuba
KEKB ring
Tsukuba exp. hall
Injection Linac
1 km
TSUKUBA Area (Belle)
BELLE
HER
LER
Interaction Region
Low Energy Ring (LER)
for Positron
High Energy Ring (HER)
for Electron
WIGGLER
RF
NIKKO Area
OHO Area
(TRISTAN Accumulation Ring)
Electron
Positron
e+/e-
HER
LER
Linac
RF
FUJI Area

SuperKEKB

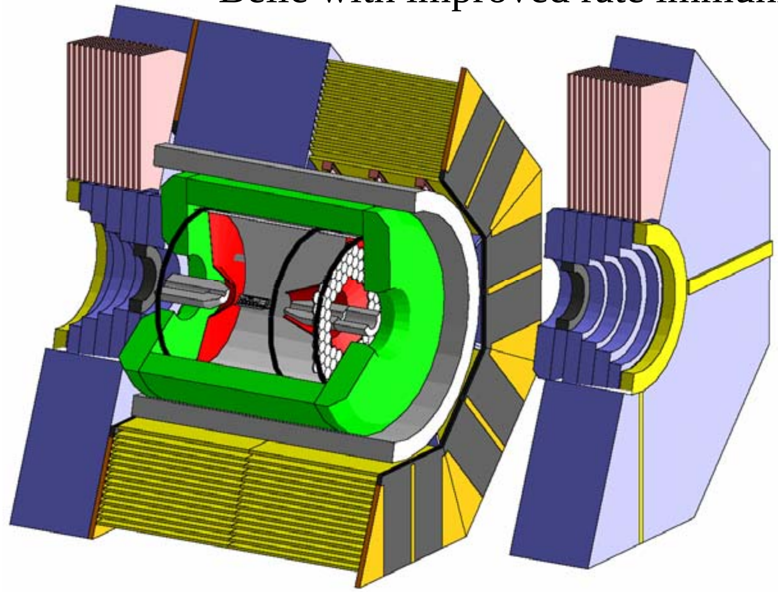
- *Asymmetric energy e^+e^- collider at E_{CM}=m(Υ(4S)) to be realized by upgrading the existing KEKB collider.*
- *Super-high luminosity* $\cong 8\times10^{35}$/cm^2/sec $\rightarrow$ 1×10^{10} *BB per yr.*

  $\rightarrow 9\times10^{9}\ \tau^+\tau^-$ *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

Three factors to determine luminosity:

Stored current:

1.36/1.75 A (KEKB)

→ 4.1/9.4 A (SuperKEKB)

Beam-beam parameter:

0.059 (KEKB)

→ >0.24 (SuperKEKB)

Lorentz factor

$$L = \frac{\gamma_{\pm}}{2 e r_e}\left(1 + \frac{\sigma_y^*}{\sigma_x^*}\right)\frac{I_{\pm}\xi_{\pm y}}{\beta_y^*}\left(\frac{R_L}{R_y}\right)$$

Classical electron radius

Beam size ratio

Geometrical reduction factors due to crossing angle and hour-glass effect

Luminosity:

0.16×10^{35} $cm^{-2}s^{-1}$ (KEKB)

8×10^{35} $cm^{-2}s^{-1}$ (SuperKEKB)

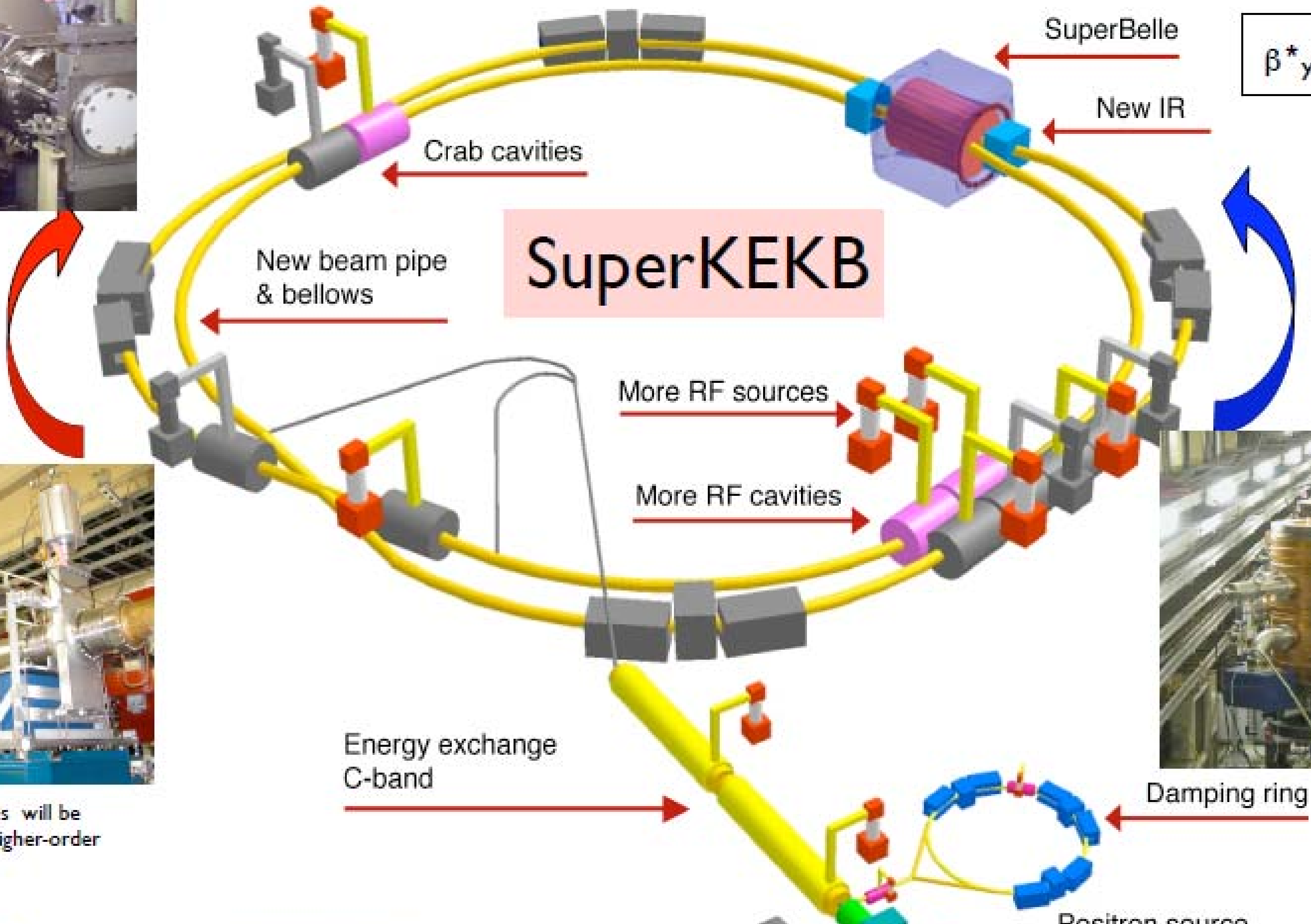
Vertical β at the IP:

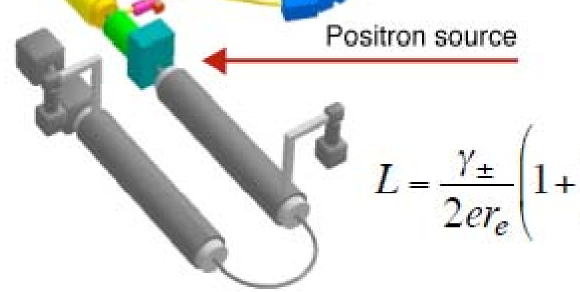
6.5/5.9 mm (KEKB)

→ 3.0/3.0 mm (SuperKEKB)

SuperKEKB

Crab cavities will be installed and tested with beam in 2006.

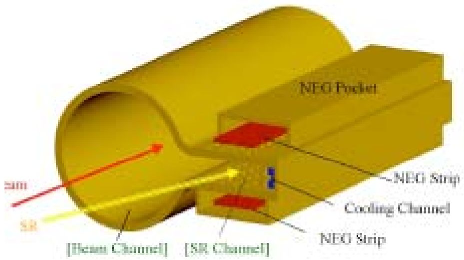


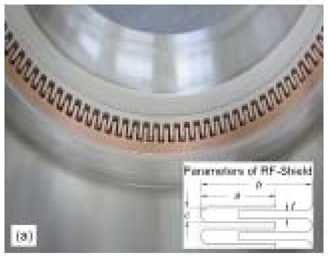


$\beta^*_y = \sigma_z = 3$ mm

The superconducting cavities will be upgraded to absorb more higher-order mode power up to 50 kW.

The state-of-art ARES copper cavities will be upgraded with higher energy storage ratio to support higher current.





The beam pipes and all vacuum components will be replaced with higher-current-proof design.

$$L = \frac{\gamma_\pm}{2er_e}\left(1+\frac{\sigma_y^*}{\sigma_x^*}\right)\left(\frac{I_\pm \xi_{\pm y}}{\beta_y^*}\right)\left(\frac{R_L}{R_y}\right)$$

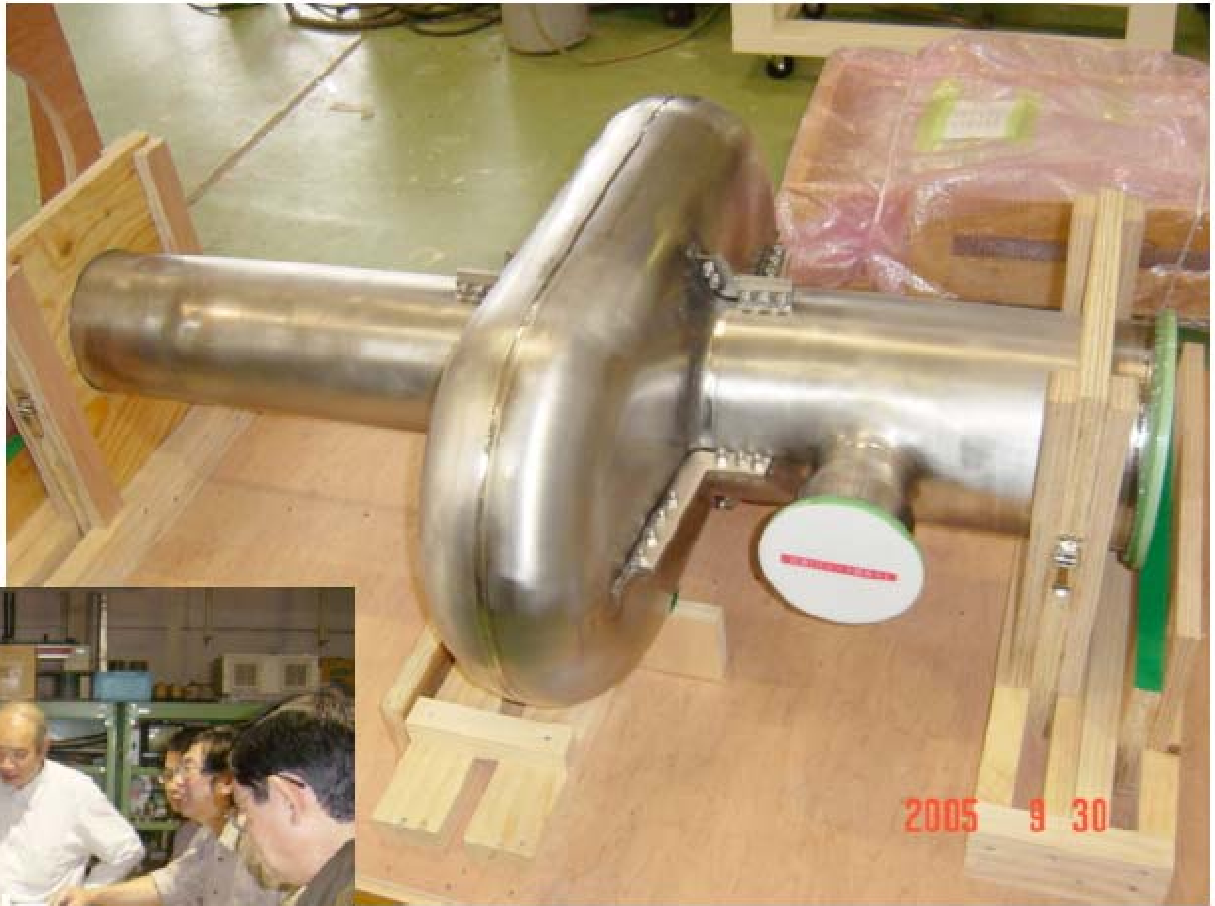
will reach 8×10^{35} cm^{-2}s^{-1}.

New Parameter Set for 8×10^{35} -- by K. Ohmi

	SuperKEKB	Crab waist			
εx	9.00E−09	6.00E−09	6.00E−09	6.00E−09	6.00E−09
εy	4.50E−11	6.00E−11	6.00E−11	6.00E−11	6.00E−11
βx (mm)	200	100	50	100	50
βy (mm)	3	1	0.5	1	0.5
σz (mm)	3	6	6	4	4
νs	0.025	0.01	0.01	0.01	0.01
ne	5.50E+10	5.50E+10	5.50E+10	3.50E+10	3.50E+10
np	1.26E+11	1.27E+11	1.27E+11	8.00E+10	8.00E+10
φ/2 (mrad)	0	15	15	15	15
ξx	0.397	0.0418	0.022	0.0547	0.0298
ξy	0.794→0.24	0.1985	0.179	0.178	0.154
Lum (W.S.)	8E+35	6.70E+35	1.00E+36	3.95E+35	4.80E+35
Lum (S.S.)	8E35	4.77E35	5.65E36	3.94E35	4.27E35

- Good parameters are not yet found with crab waist.

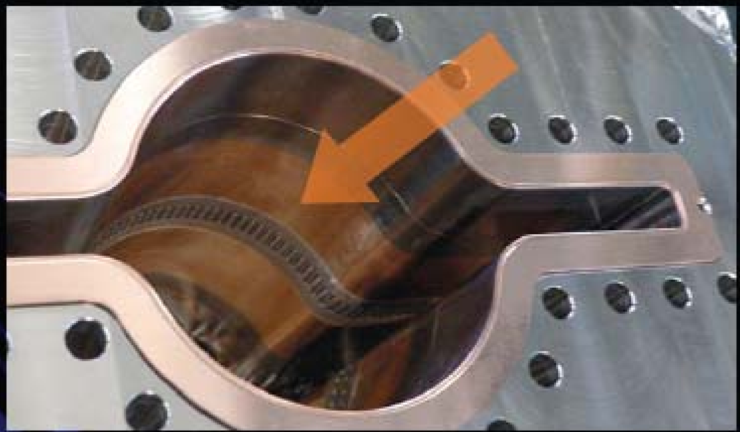
Crab cavity



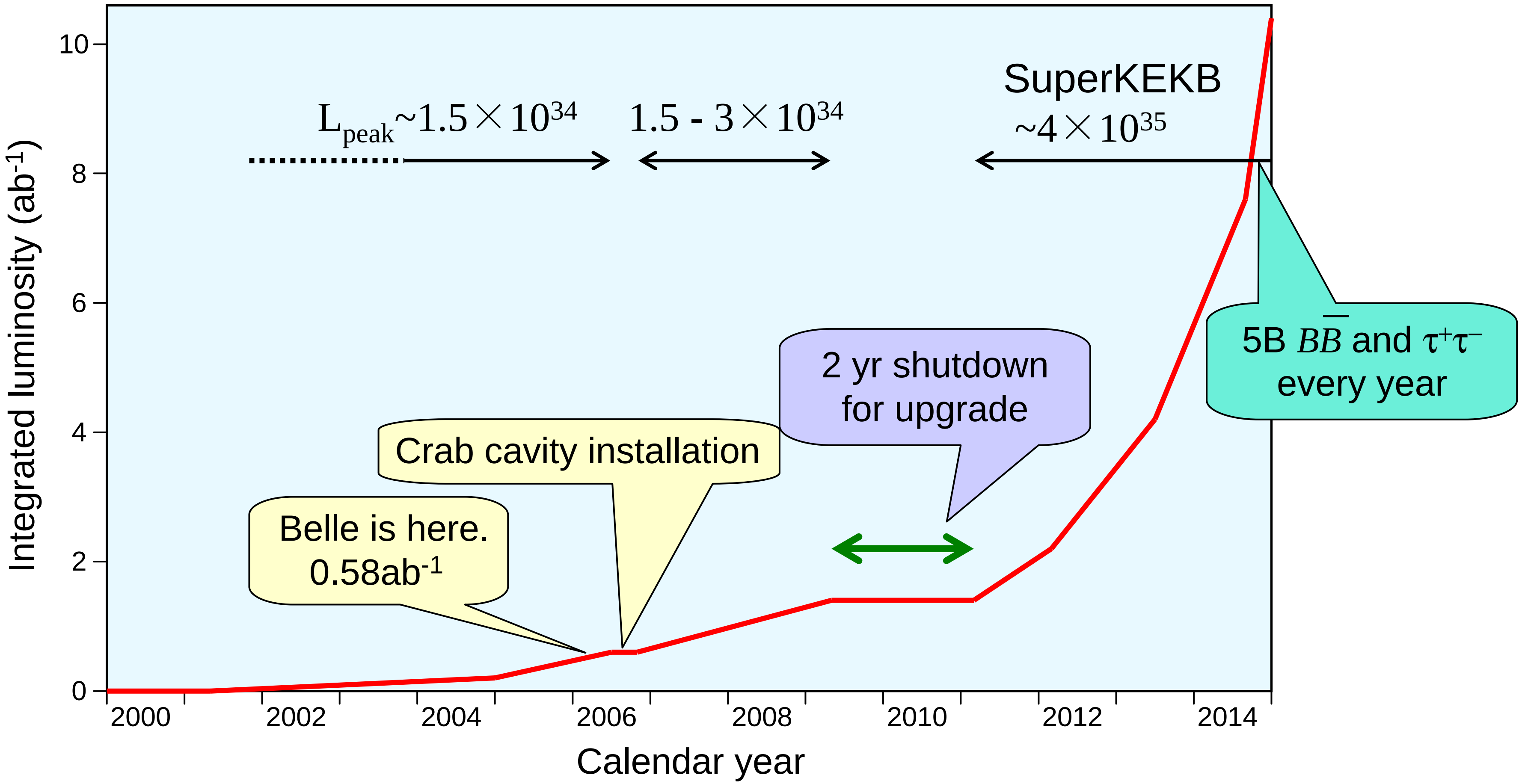
He jacket

2. Bellows Chamber and Gate Valve

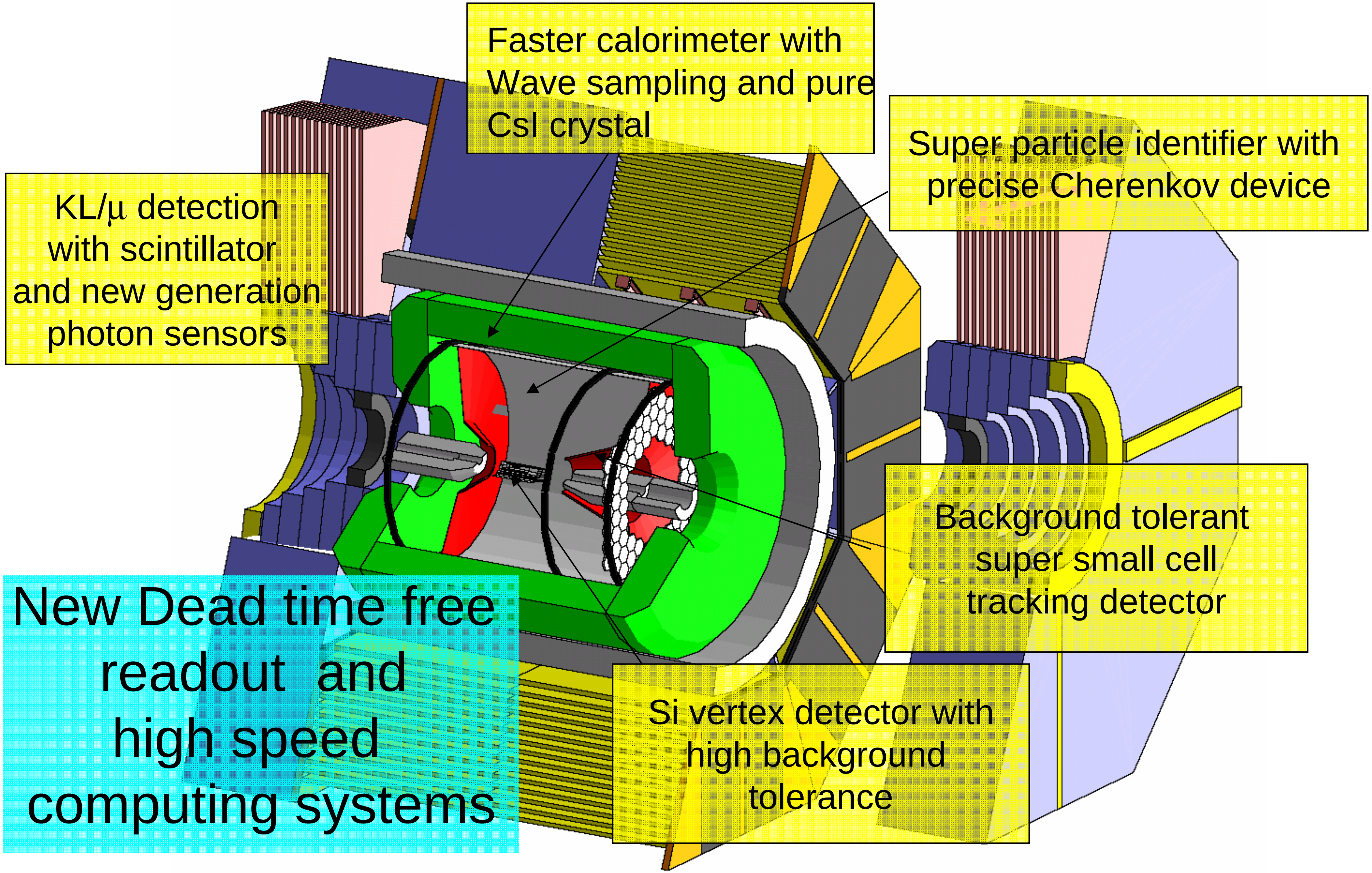
- Application of Ver.2 to antechamber-type bellows
  - Manufactured at BINP (2005)
  - Copper cooling channel
    - Improve cooling of teeth
  - Two bellows chamber were installed into LER wiggler (2005).
  - No problem was found up to 1.7 A.



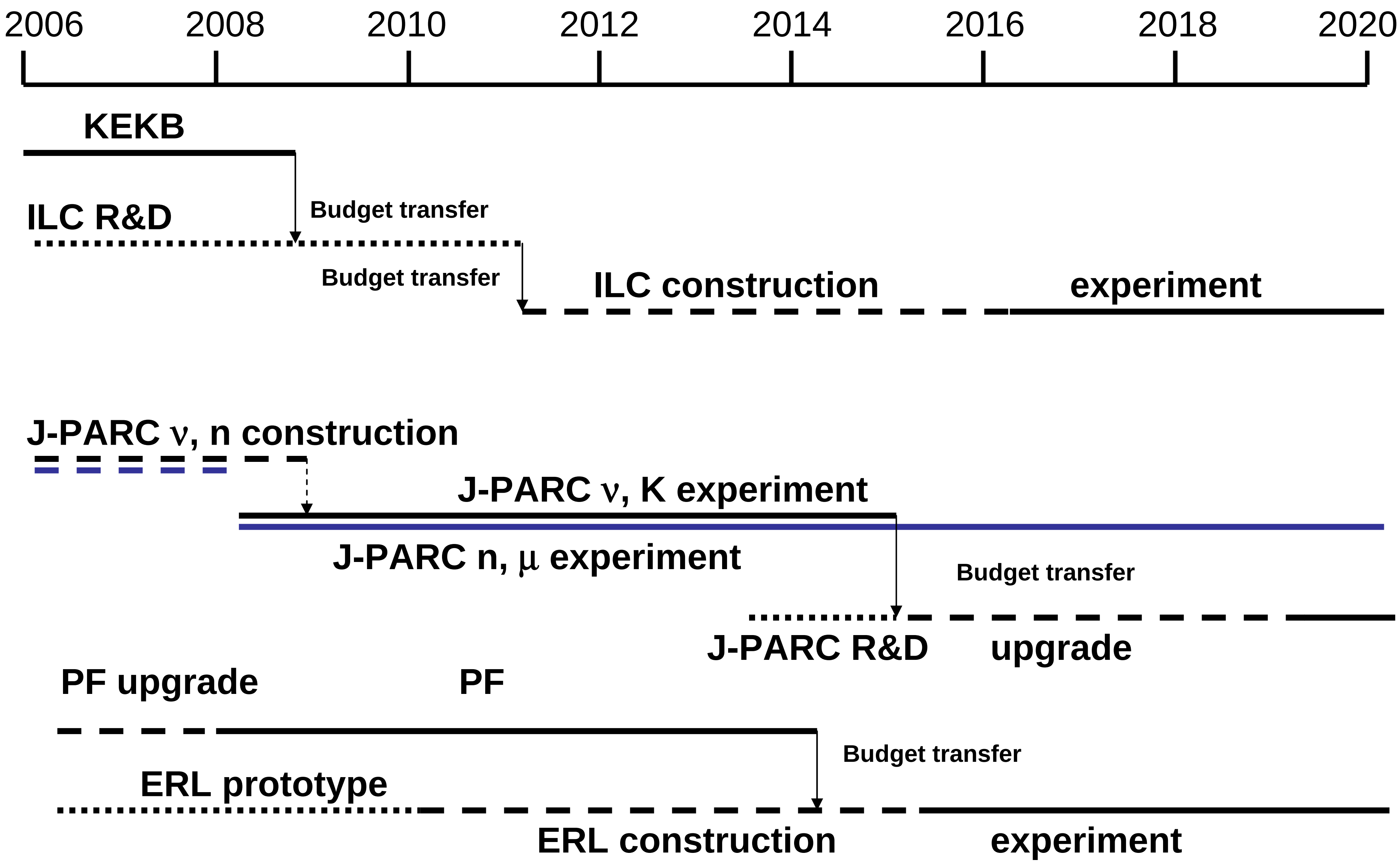
Proposed schedule



Super Belle

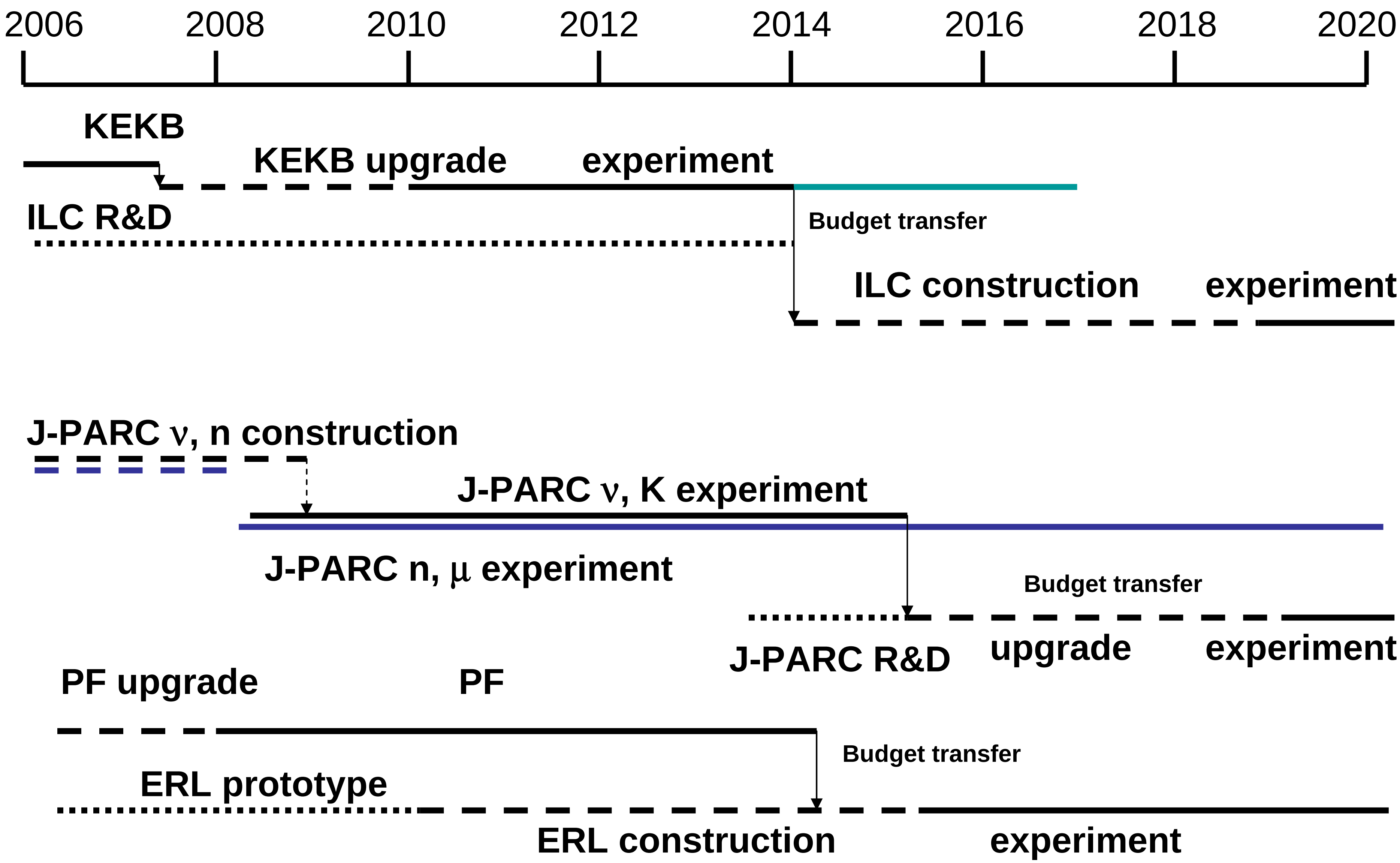


Faster calorimeter with Wave sampling and pure CsI crystal
KL/μ detection with scintillator and new generation photon sensors
Super particle identifier with precise Cherenkov device
Background tolerant super small cell tracking detector
New Dead time free readout and high speed computing systems
Si vertex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



Scenario Version 1

By previous KEK management



Scenario Version 2

By previous KEK management

From B Factories to Super B factories

$$L = \frac{N_{e^+} N_{e^-}}{4\pi \ \sigma_x \sigma_y} f_{\text{collision}}$$

- Traditional design of B factories hits fundamental limits when scaled to $10^{36}/cm^2 s$:

– Bunch Disruption: ($N\sigma_z/\sigma_x\sigma_y$) upper bound set by beam-beam effects

– Hour glass effect ($\beta_y < \sigma_z$): lowering σ_y (and thus β_y) is ineffective

– Wall-plug power limit: upper bound on the Collision frequency

- **New ideas... a new machine concept is needed !**

- high luminosity from small σ_y <u>and</u> σ_z but also low disruption

Damping ring: ILC-like rings

- OCS lattice used (ILC D.R. are 6.0km Circumference)
- Scaled to 4 and 7 GeV (Υ4S)
- Shortened to 3.2 Km (2.4 Km also possible)
- Wiggler field 1.4 T (permanent magnet)

Total Wall Power (60% transfer eff.): 32 MW
Energy cost per produced B meson:16KJ/B
Efficiency 50 x of the present B factories

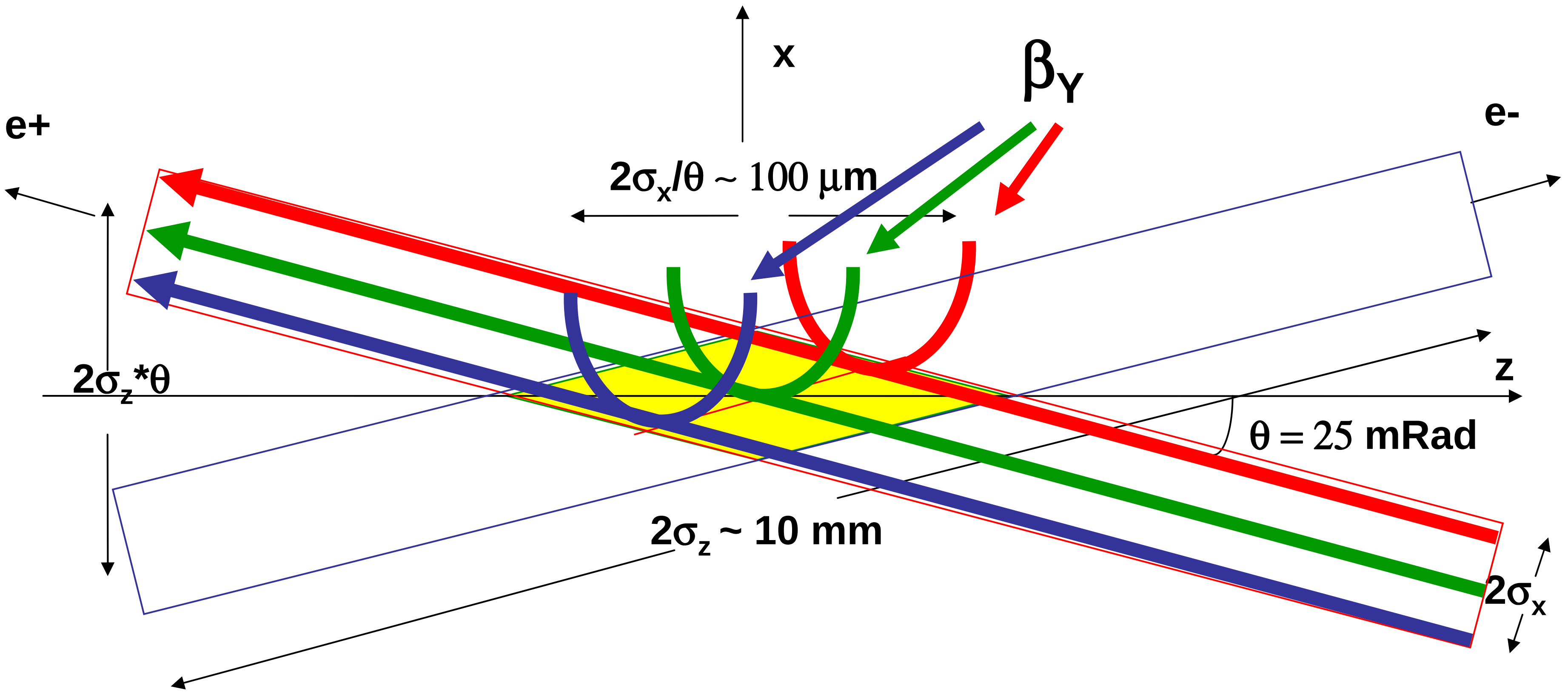
SuperB

Parameters set

Sigx*	μm	2.67
Sigy	nm	12.6
Betx	mm	9.0
Bety	mm	0.080
Sigz_IP	mm	6.0
Sige_IP		1.3e-3
Sige_Lum		0.9e-3
Emix	nm	0.8
Emiy	nm	0.002
Emiz	μm	8.0
Cross_angle	mrad	2*25
Sigz_DR	mm	6.0
Sige_DR		1.3e-3
Np	10e10	2.3
Nbunches		6000
DR_length	km	3.0
Damping_time	msec	20
Collision freq	MHz	600
$L_{multiturn}$	10^{36}	1.0

- **Defined a parameters set based on ILC-like parameters**
- **Same Damping Ring (DR) emittances**
- **Same DR bunch length**
- **Same DR bunch charges**
- **Same DR damping time**
- **Same ILC-IP betas**
- **Crossing Angle and Crab Waist to minimize Beam Beam blowup**

Crabbed focus: displace along Z the waist position for left, center, right particles



•All components of the beam collide at a minimum β_y :

- the 'hour glass' is reduced (effective luminous region length ~ 100 μm)
- the geometric luminosity is higher (5-10%)
- the beam beam effects are reduced (factor 2-4)

P.Raimondi

SuperB

Features

- Expected background in the detector lower than in PEPII (it allows a beam pipe diameter smaller than in PEPII/Babar).
- One polarized beam is also considered (an ad hoc subcommittee is presently looking to possible gains in physics from polarization)

More on machine

- Luminosity upgradeable by a substantial factor towards 10^{37}.
- Site to be chosen according to possible offer by Laboratories and funding agencies.
- Full international collaboration should be foreseen to build and run machine and detector.

Documents

- The Discovery Potential of a Super B Factory
  (SLAC-R-709)
- Letter of Intent for KEK Super B Factory
  (KEK Report 2004-4)
- Physics at Super B Factory (hep-ex/0406071)
- At the URL :
  – http://belle.kek.jp/SuperB
  – http://www.pi.infn.it/SuperB

SuperKEKB Internationalization

- "KEK + in-kind contribution from the others" is a favorable scenario for KEK.
  - 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.
  - Submit joint proposals to the possible host labs.

International study group

An international Study Group was set up coordinated by a steering committee with the aim of preparing a document (CDR) by the end of 2006. We had 2 workshops in Frascati:

November2005

March 2006

Next 2 workshops :

- 14-17june 06 in SLAC
- october 06 in Rome (Parallel :Theory, Expt., Machine)

An Steering committee is coordinating the group activity

M.A.G. coordinator

Members: 1 Canada,2 France, 2 Germany, 2 Italy, 2 Russia, 2Spain, 2 UK, 4 US.

Activity is documented in

http://www.pi.infn.it/SuperB

Summary

- KEKB/Belle and PEP-II/BaBar have been running very successfully, and brought important scientific achievements.
- 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
  - How? – Increase N_B, decrease β_y*, and crab crossing: $L=8\times10^{35}/cm^2/s$
  - What? – New beam pipe, crab cavity, new injector with damping ring. Belle will also be upgraded assuming DC is usable.
  - Where and when? – Upgrade existing KEKB in 2009-2010.
- ILC inspired SuperB being proposed
  - ILC-like damping rung + final focus to achieve >10^{36}.
  - O(1)A beam current → lower detector background
  - Wall plug power ~32MW < KEKB/PEP-II
- Internationalization will be necessary for any Super B Factory to be realized.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MCU アルク 会議室予約 辞書 世界時計 天気 路線 カレンダー @nifty Active! mail 2003
The International Workshop on
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Top Bulletin Registration Program Proceedings KEK
Sep. 13-14, 2006
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Topics
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