Super KEKB

Masashi Hazumi *(KEK)*

An executive summary to explain 5W1H:

- **What** is Super KEKB ?
- **When** will Super KEKB start ?
- **Who** are we ?
- **Where** do we stand ?
- **Why** do we need Super KEKB ?
- **How** is Super KEKB designed ?

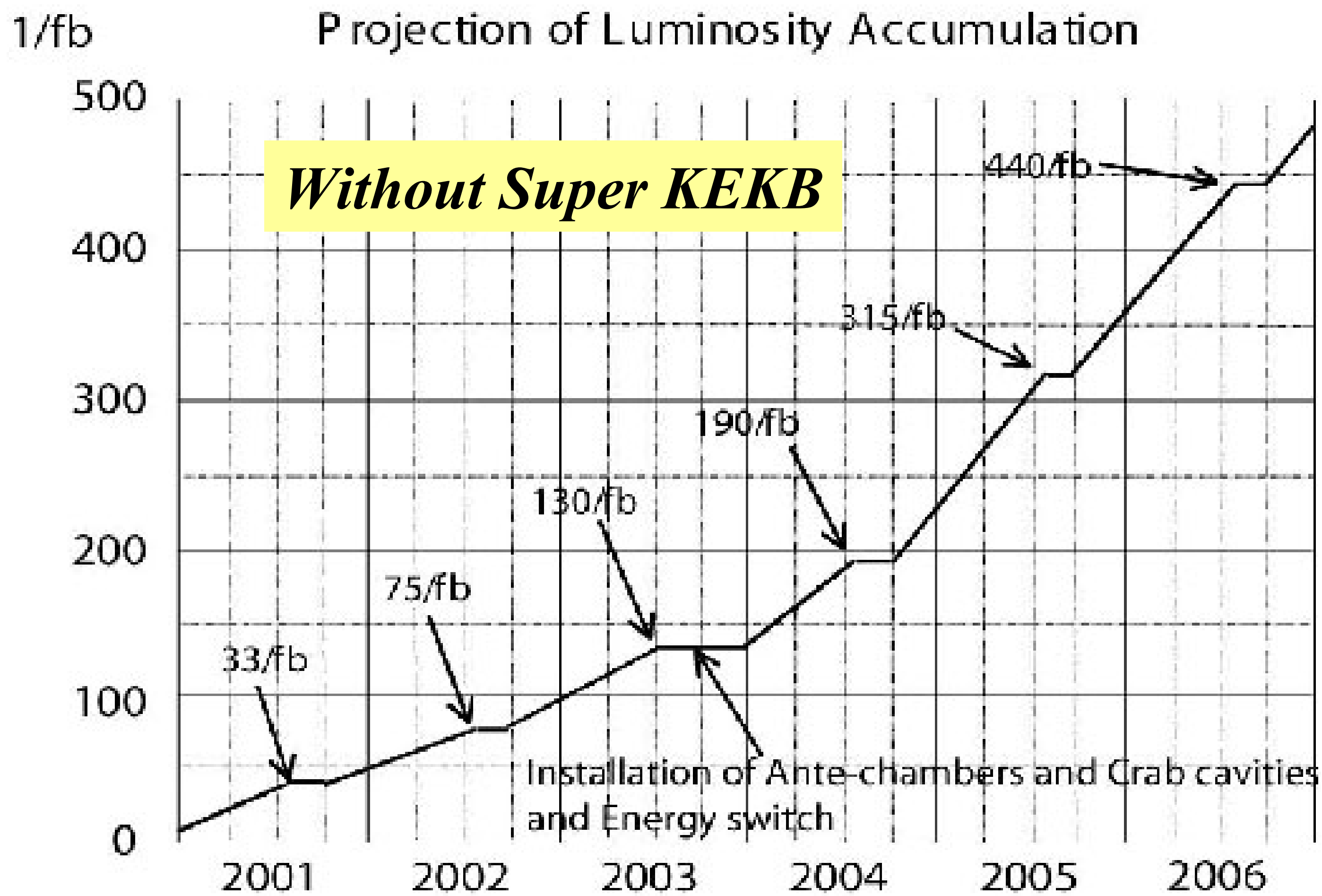
What is Super KEKB ?

- A high luminosity upgrade of the existing KEKB Collider and the Belle Detector.
- Target luminosity of 10^{35} $cm^{-2}s^{-1}$ (x 20 as large as the present level), which is quite feasible !
- **Physics programs complementary and competitive to hadron experiments.**
  - **Beyond SM (e.g. SUSY flavor physics)**
  - **Final states with neutrals.**
  - **Inclusive measurements.**
  - **Direct CP Violation in many modes.**

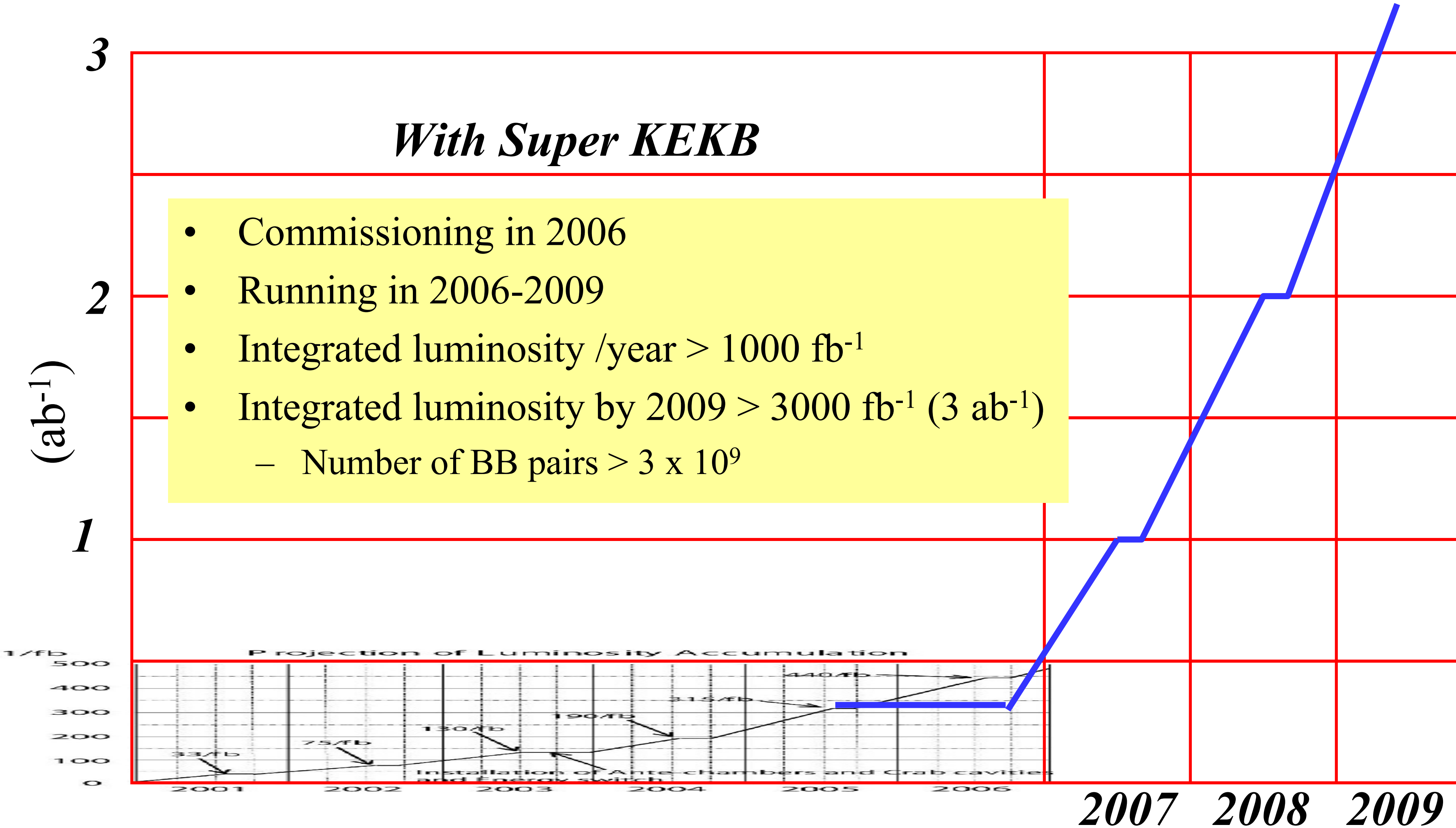
Clean Environment !

When will Super KEKB start ?

- Commissioning in 2006



When will Super KEKB start ?



- Commissioning in 2006
- Running in 2006-2009
- Integrated luminosity /year > 1000 fb^{-1}
- Integrated luminosity by 2009 > 3000 fb^{-1} (3 ab^{-1})
  - Number of BB pairs > 3×10^9

Who are we ? Where do we stand ?

- "Expression of Interest" (EoI) with more than 200 people from 42 institutions.

I. Abe[8], K. Abe[8], T. Abe[35], I. Adachi[8], H. Aihara[36], K. Akai[8], A. Akiyama[8], K. Aoki[8], M. Arinaga[8], T. Aushev[12], S. Banerjee[33], A. Bay[16], A. M. Bakich[34], Y. Ban[38], P. K. Behera[39], I. Bizjak[13], A. Bondar[1], M. Bračko[18,13], T. E. Browder[7], P. Chang[22], B. G. Cheon[32], Y. Choi[32], Y. Doi[8], A. Drutskoy[12], K. Ebihara[8], E. Egawa[8], S. Eidelman[1], V. Eiges[12], K. Endo[8], A. Enomoto[8], E. Ezura[8], J. W. Flanagan[8], H. Fujii[8], S. Fukuda[8], H. Fukuma[8], Y. Funakoshi[8], K. Furukawa[8], T. Furuya[8], T. Gershon[8], B. Golob[17,15], A. Gordon[19], H. Guler[7], J. Haba[8], K. Hagiwara[8], K. Hara[26], T. Hara[8], T. Haruyama[8], S. Hashimoto[8], H. Hayashii[21], M. Hazumi[8], T. Higuchi[36], L. Hinz[16] S. Hiramatsu[8], H. Hisamatsu[8], T. Honda[8], H. Honma[8], K. Hosoyama[8], T. Ieiri[8], Y. Igarashi[8], N. Iida[8], T. Iijima[8], H. Ikeda[8], M. Ikeda[8], S. Isagawa[8], H. Ishii[8], H. Ishino[37], R. Itoh[8], Y. Iwasaki[8], D. J. Jackson[26], H. K. Jang[31], A. Kabe[8], T. Kageyama[8], K. Kakihara[8], S. Kamada[8], N. Kamikubota[8], T. Kamitani[8], K. Kanazawa[8], J. H. Kang[42], H. Katagiri[8], N. Katayama[8], S. Kato[8], T. Katoh[8], S. Kawabata[8], H. Kawai[3], T. Kawamoto[8], T. Kawasaki[24], H. Kichimi[8], M. Kikuchi[8], E. Kikutani[8], H. J. Kim[42], T. H. Kim[42], K. Kinoshita[5], S. Kobayashi[37], H. Koiso[8], Y. Kojima[8], I. Komada[8], P. Koppenburg[16], S. Korpar[18,15], P. Križan[17,15], T. Kubo[8], K. Kudo[8], S. Kumar[27], T. Kurimoto[28], S. I. Kurokawa[8], A. Kuzmin[1], Y.-J. Kwon[42], J. S. Lange[6], J. S. Lee[8], J. MacNaughton[11], G. Majumder[33], Y. Makida[8], A. Manabe[8], F. Mandl[11], M. Masuzawa[8], T. Matsumoto[8], S. Michizono[8], T. Mimashi[8], T. Mitsuhashi[8], S. Mitsunobu[8], K. Miyabayashi[21], H. Mizuno[8], G. R. Moloney[19], K. Mori[8], Y. Morita[8], T. Morozumi[9], T. Naito[8], T. Nakadaira[36], H. Nakai[8], H. Nakajima[8], T. T. Nakamura[8], H. Nakanishi[8], E. Nakano[25], K. Nakao[8], M. Nakao[8], H. Nakayama[8], H. Nakazawa[4], J. W. Nam[42], S. Nishida[13], S. Noguchi[21], T. Nozaki[8], J. Odagiri[8], Y. Okada[8], Y. Ogawa[8], K. Ohmi[8], T. Ohshima[20], Y. Ohnishi[8], S. Ohsawa[8], Y. Ohsawa[8], N. Ohuchi[8], K. Oide[8], S. Okuno[14], S. L. Olsen[7], M. Ono[8], T. Oogoe[8], H. Ozaki[8], T. Ozaki[8], H. Palka[23], L. S. Peak[34], J.-P. Perroud[16], M. Peters[7], L. E. Piilonen[40], S. Recksiegel[8] M. Rozanska[23], H. Sagawa[8], H. Sakai[8], Y. Sakai[8], Y. Sakamoto[8], A. Satpathy[8,5], K. Satoh[8], M. Sato[8], S. Schrenk[5], K. Senyo[20], T. Shidara[8], M. Shimamoto[8], M. Shirai[8], A. Shirakawa[8], B. Shwartz[1], J. B. Singh[27], N. Soni[27], M. Starič[13], M. Suetake[8], Y. Suetsugu[8], R. Sugahara[8], K. Sumisawa[8], T. Sumiyoshi[8], T. Suwada[8], K. Suzuki[3], S. Suzuki[41], S. Y. Suzuki[8], T. Tajima[8], F. Takasaki[8], S. Takeda[8], Y. Takeuchi[8], K. Tamai[8], J. Tanaka[36], M. Tanaka[8], M. Tanaka[26], M. Tawada[8], G. N. Taylor[19], M. Tejima[8], Y. Teramoto[25], M. Tobiyama[8], T. Tomura[36], K. Trabelsi[7], T. Tsuboyama[8], K. Tsuchiya[8], T. Tsukamoto[8], S. Uehara[8], S. Uno[8], Y. Ushiroda[8], K. E. Varvell[34], J. G. Wang[40], Y. Watanabe[37], E. Won[31], B. D. Yabsley[8], Y. Yamada[8], H. Yamamoto[35], M. Yamauchi[8], Y. Yano[8], M. Yokoyama[36], M. Yoshida[8], S. Yoshimoto[8], M. Yoshioka[8], C. C. Zhang[10], Z. Zhang[10], and F. Zimmermann[2]

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[2]CERN, SL Division, CH-1211 Geneva 23
[3]Chiba University, Chiba
[4]Chuo University, Tokyo
[5]University of Cincinnati, Cincinnati OH
[6]University of Frankfurt, Frankfurt
[7]University of Hawaii, Honolulu HI
[8]High Energy Accelerator Research Organization (KEK), Tsukuba
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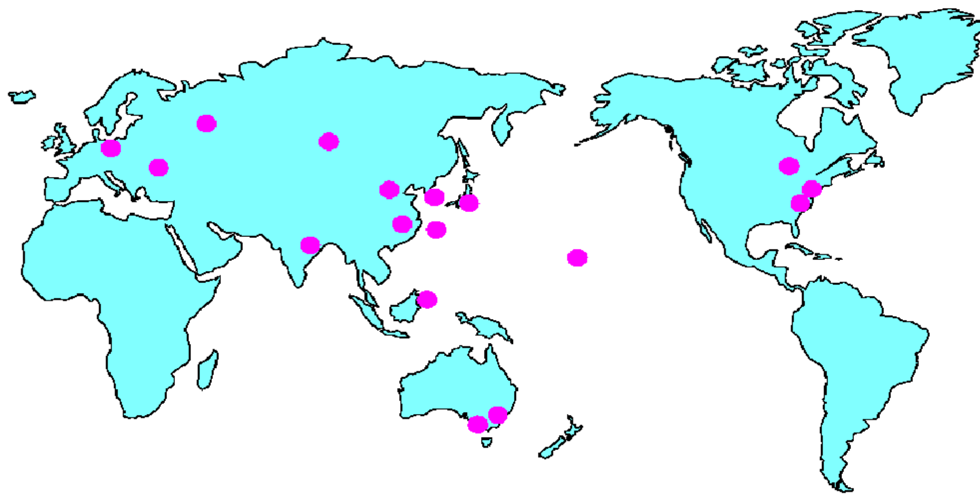
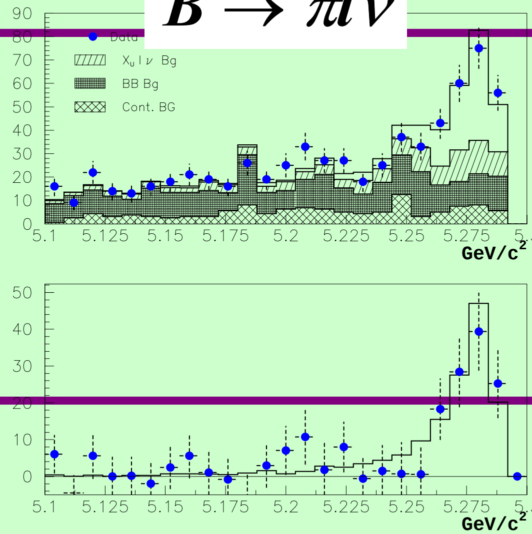


EoI will be available as a hep-ex article soon.

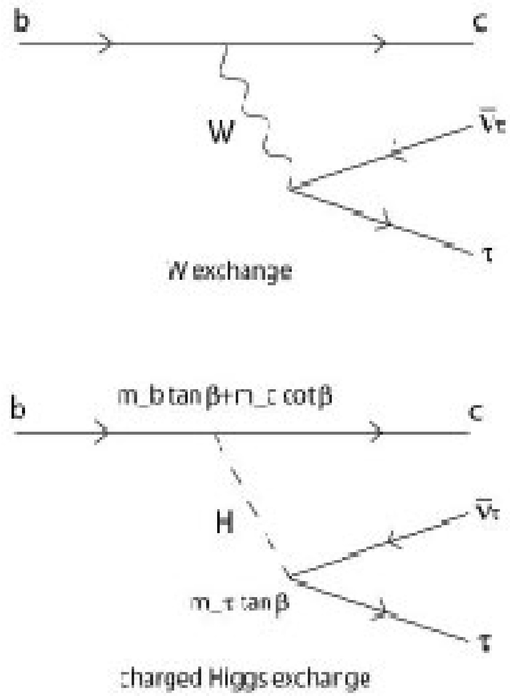
Why do we need Super KEKB ?

- Ideal place to study flavor physics beyond the SM.
  - New amplitudes (mostly FCNC)
  - New CP violating phases
- Final states with neutrals (ν, π^0, γ, K_L, ϕ)
  - $B^0 \rightarrow D\tau\nu$, $l\nu(\gamma)$, $K^*\nu\nu$
  - $B^0 \rightarrow \phi Ks$, $\eta' Ks$ *(for new CP violating phases)*
  - $B^0 \rightarrow \pi^0\pi^0$ *(for precise measurement of* $sin2\phi_2$*)*
  - $B \rightarrow \pi l \nu$
- *Inclusive* measurements
  - $b \rightarrow sl+l-$, $b \rightarrow s\gamma$, $b \rightarrow d\gamma$
- Direct CP violation in many modes → ***CPV factory*** !
- ***3000fb^{-1} enough for many cases. Important to achieve it as early as possible.***
- If SUSY is discovered at LHC, our target will be clearer
  - SUSY flavor problem
  - SUSY CP problem

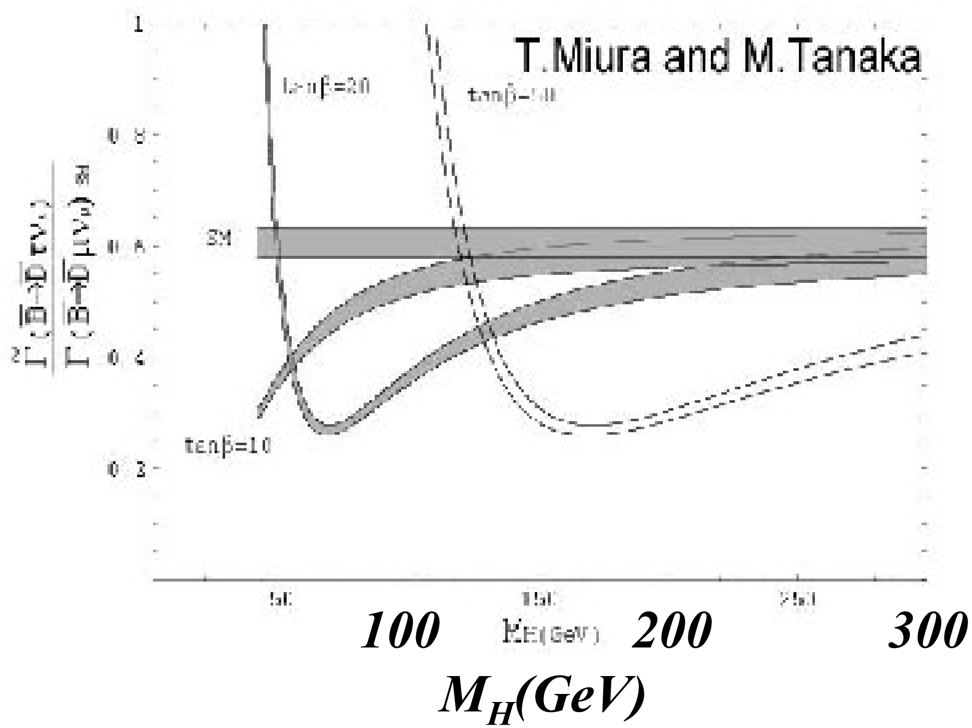
$B \rightarrow \pi l \nu$



Example: B→Dτν, Charged Higgs at tree level



- Large Br of O(1)%
- Uncertainty in form factor cancels.
- τ polarization: exp. challenge



Need >1000fb^{-1}

Full reconstruction technique (eff ~ 0.2%) will be used.

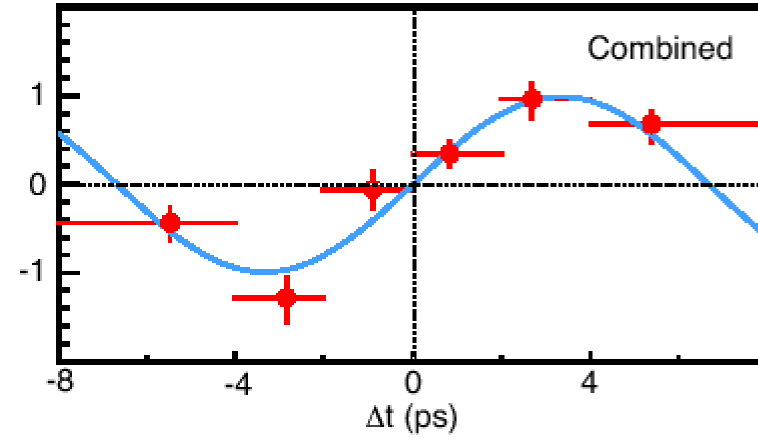
Example: Search for new CP-violating phases (ϕ_{NP})

CP eigenstates at Belle as of July 2001

- **For sin2ϕ1 analysis**

	candidates	purity	int. lumi.
$J/\psi\, Ks(\rightarrow\pi^+\pi^-)$	457ev.	97%	29.1fb^{-1}
Other (cc) Ks	290ev.	84%	29.1fb^{-1}
$J/\psi\, K_L$	569ev.	61%	29.1fb^{-1}

sin2ϕ1 = 0.99 ±0.14 ±0.06



- **"Rare" decays**

$\phi\,(\rightarrow K^+K^-)\,Ks$	10ev.	80%	21.3fb^{-1}
η' Ks	26ev.	63%	10.4fb^{-1}
$D^*D^{(*)}$	27ev.	82%	21.3fb^{-1}
$Ks\,\pi^0$	12ev.	67%	10.4fb^{-1}

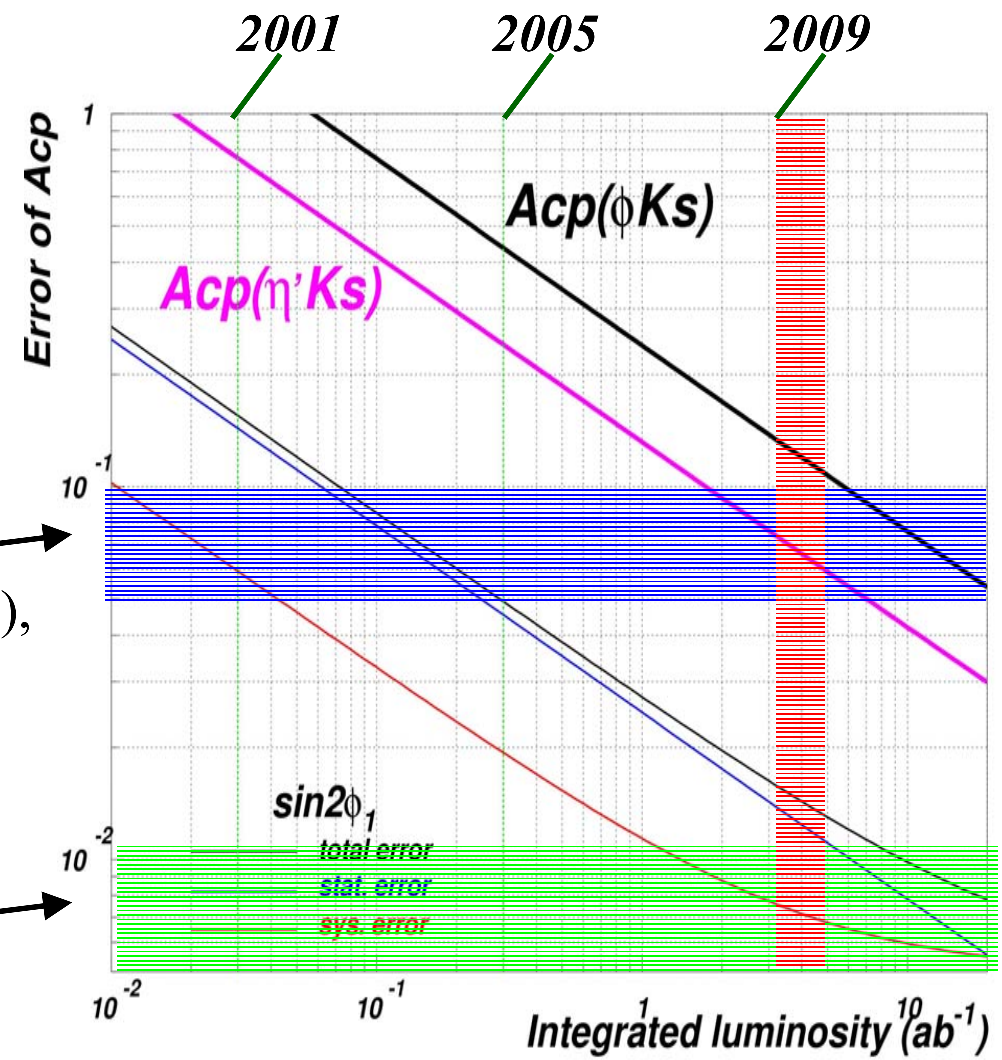
	Penguin	Tree
$b \rightarrow$	$s\bar{s}s$	$(u\bar{u}s)$
$b \rightarrow$	$s\bar{u}u$, $s\bar{d}d$	$u\bar{u}s$
$b \rightarrow$		$u\bar{c}d$, $c\bar{c}d$
$b \rightarrow$	$d\bar{d}s$,	$u\bar{u}s$, $d\bar{d}s$

Expected CP Reach for ϕ_{NP}

We can reach the level of hadronic uncertainties.

Hadronic uncertainties in new phase measurements Grossman, Isidori, Worah (1998), London and Soni (1997)

Hadronic uncertainties in sin2ϕ1 measurements



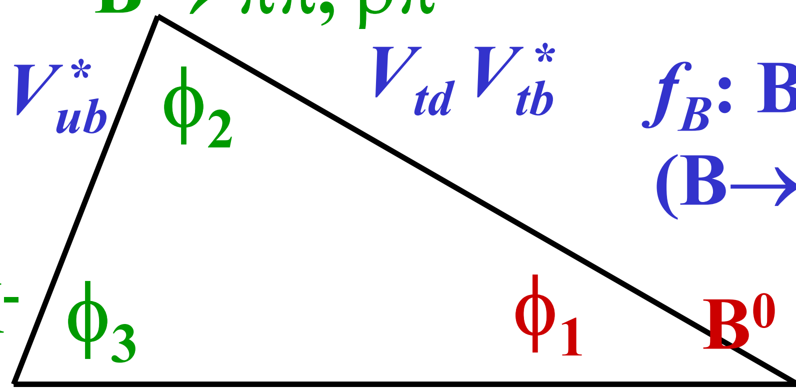
Goals of Rare B Decay Program

1) Discover / Establish "Direct" CPV
2) Precise Measurements of CKM elements :
→ ***angles*** **and** ***lengths***
3) ***Beyond SM***

$B \to \pi\pi, \rho\pi$

$B \to \pi l \nu$
$B \to D_s \pi$

$V_{ud} V_{ub}^*$



$V_{td} V_{tb}^*$

f_B: $B \to l\nu$
($B \to \rho\gamma$)

$B^- \to D_{CP} K^-$
$B \to \pi\pi/K\pi$
$B \to$ 3 body

$B^0 \to \eta' K_s, \phi K_s$
$B^0 \to D^{*+} D^{(*)-} (K)$

$V_{cd} V_{cb}^*$

$B^0 \to D^{(*)-} l^+ \nu$, dileptons

EM/EW Penguin : $B \to K_x \gamma$, $B \to K l^+ l^-$

Sensitivity Comparisons

Table 2.1: Summary of the estimated precision of CP-violating amplitudes in the proper-time distributions at KEKB/Belle, Super KEKB and planned experiments at LHC. The column labeled by "NP−SM" is the maximum deviation from the SM prediction due to an effect of New Physics (NP). Items marked with "×" cannot be measured at the experiment in question. No information is available for the blank entries.

Decay mode	Theory		KEKB	Super KEKB	LHC		
	SM	NP−SM	(0.3ab^{-1})	(3ab^{-1})	LHCb	ATLAS	CMS
$J/\psi K_S$ etc.	$\sin 2\phi_1$	~ 0.1	0.049	0.016	0.014	0.021	0.025
ϕK_S	$\sin 2\phi_1$	~ 1	0.44	0.14			
$\eta' K_S$	$\sin 2\phi_1$	~ 1	0.24	0.076			
$\pi^+\pi^-$	$\sin 2\phi_2^{eff}$	–	0.19	0.060	0.056	0.10	0.17
$\pi^0\pi^0$ etc.	$\phi_2 - \phi_2^{eff}$	–	20°	7°	×	×	×
$D^*\pi$	$\sin(2\phi_1+\phi_3)$	–	0.24	0.077			
$K_1\gamma$	$\sim m_s/m_b$	~ 0.6	0.77	0.24	×	×	×
$\rho\gamma + \omega\gamma$	$\sim m_d/m_b$	~ 0.6	0.42	0.13	×	×	×

Decay mode	Parameter	KEKB	Super KEKB	LHC		
		(0.3ab^{-1})	(3ab^{-1})	LHCb	ATLAS	CMS
DK	ϕ_3	14°	5°	19°		
$\pi(\rho)\ell\nu$	$\lvert V_{ub}\rvert$	4.3%	1.4%	×	×	×
inclusive lepton	$\lvert V_{ub}\rvert$	2.6%	0.8%	×	×	×

How is Super KEKB designed ?

- Peak luminosity: 10^35 $cm^{-2}s^{-1}$ (10^9 BB pairs/year)
  - Squeeze beam size at IP(βy*) (6.5~7 → 3 mm)
  - Squeeze bunch length (5~6 → 3 mm)
  - Larger crossing angle (2 x 11 → 2 x 15 mrad)

Evolution rather than Revolution

  - Larger beam currents, overcoming photo-electron instability

	KEKB	→	SuperKEKB
Beam Energy (e−)	8.0 GeV	→	3.5 GeV
(e+)	3.5 GeV	→	8.0 GeV !!

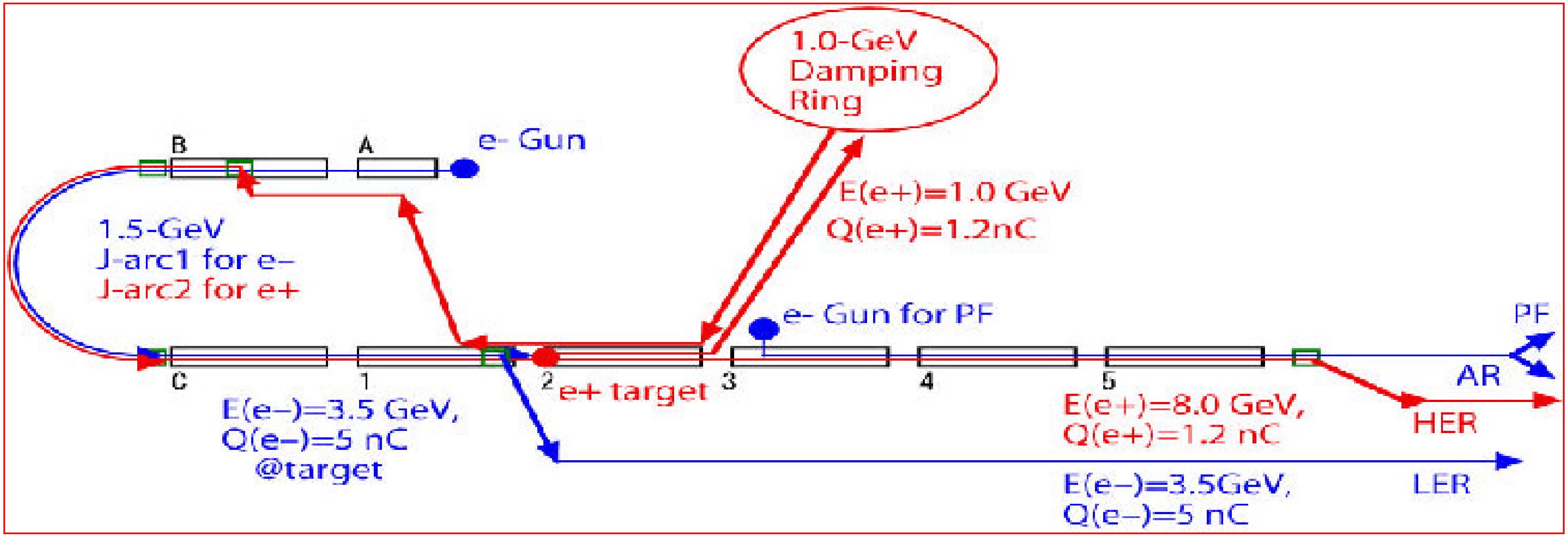
NEED Energy upgrade for e + !

	July 2001	KEKB design	SuperKEKB
stored current (e−)	0.8 A →	1.1 A →	10.0 A !!
(e+)	0.9 A →	2.6 A →	3.0 A !!

NEED Intensity upgrade for e−/e+ !

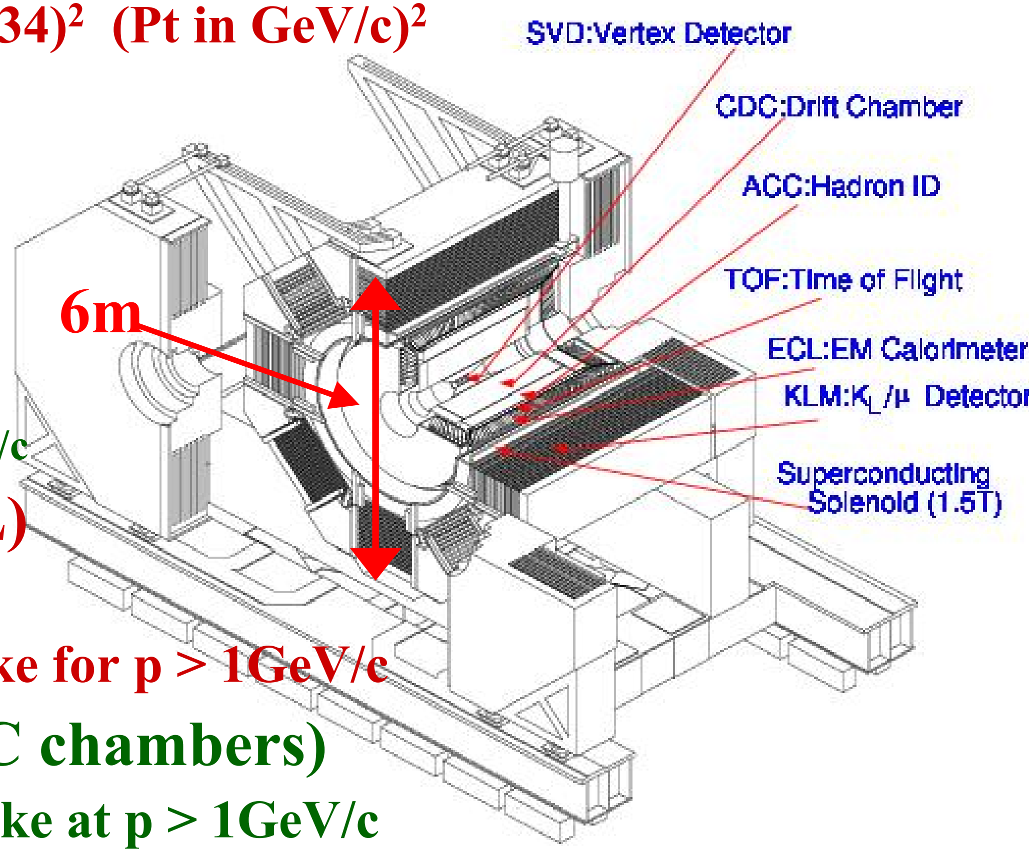
Injection Linac

- Two options to achieve 8GeV positrons
  - C-band option 21 → 40 MV/m
  - Recirculation option



Belle Detector Performance

- **Silicon Vertex Detector (SVD)**
  - **Impact parameter resolution : 55μm for p=1GeV/c at normal incidence**
- **Central Drift Chamber (CDC)**
  - **$(\sigma_{Pt}/Pt)^2 = (0.0019Pt)^2 + (0.0034)^2$ (Pt in GeV/c)^2**
- **K/π separation with**
  - **dE/dx in CDC ($\sigma_{dE/dx}$ =6.9%)**
  - **TOF (σ_{TOF} = 95ps)**
  - **Aerogel Cerenkov (ACC)**
    - **Efficiency = ~85%,**
      Fake rate = ~10% up to 3.5GeV/c
- **γ, $e^{\pm}$ with CsI crystals (ECL)**
  - **σ_E/E ~ 1.8% @ E=1GeV**
  - **$e^{\pm}$: effic. > 90% w/ ~0.3% fake for p > 1GeV/c**
- **K_L and $\mu^{\pm}$ with KLM (RPC chambers)**
  - **$\mu^{\pm}$: effic. > 90% with ~2% fake at p > 1GeV/c**



Detector upgrade issues

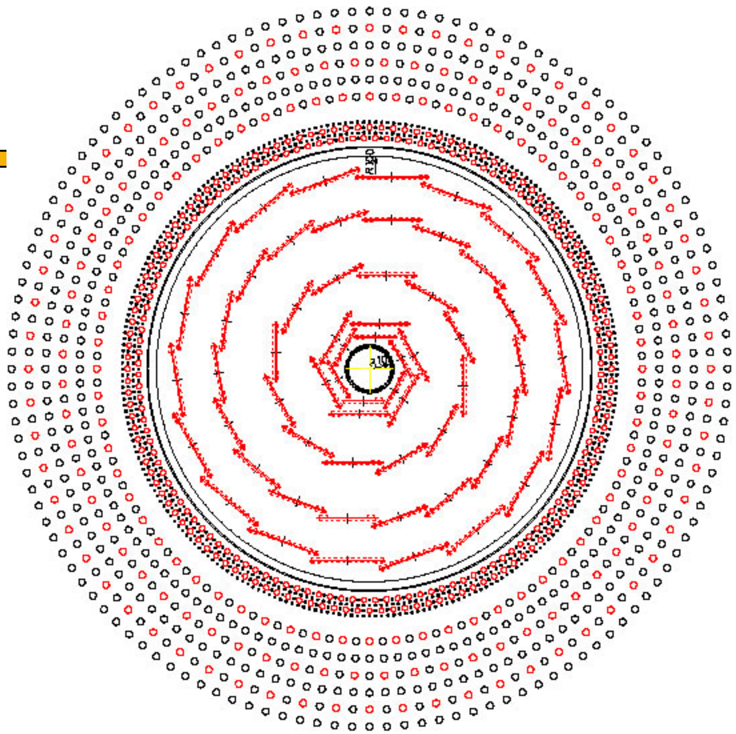
Component	Upgrade requirements
Vertex meas.	σ=100μm→30μm, smaller radius pixel?
Tracking	Probably OK
Calorimetry	Fake photons → shorter shaping time?
π/K separation	Various new ideas
μ ID	RPC → wire chamber?
Electronics	Fully pipelined digitizer
DAQ	x20 throughput
Computing	x100 computing power

Present technologies are sufficient in most of the cases.

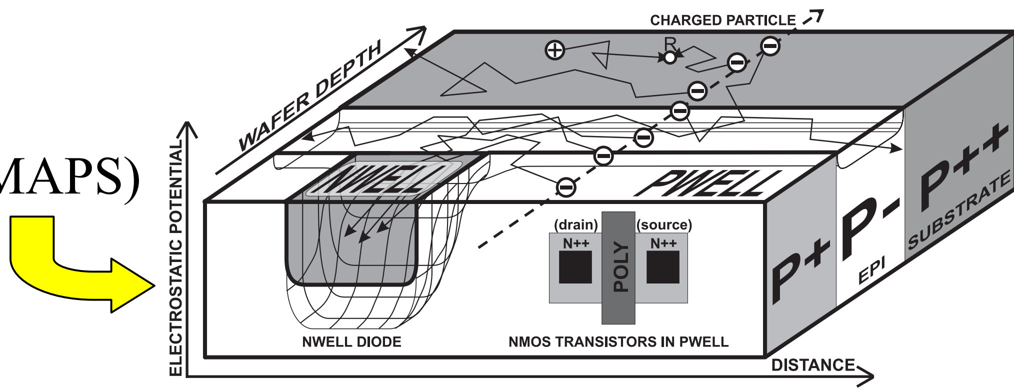
However, we prefer to improve the performance as much as possible.

Vertex Measurements

- Better vertex resolution for background rejection
  - Beampipe radius of 1cm
  - Rad. Hard (~7 MRad/year)
  - Occupancy should be low enough.
- DSSDs not possible for the innermost layer → Pixel
- DSSDs should cover larger volume (in radius)
- Pixel candidates
  - Monolithic Active Pixel Sensor (MAPS)
  - Hybrid pixel
  - CCD

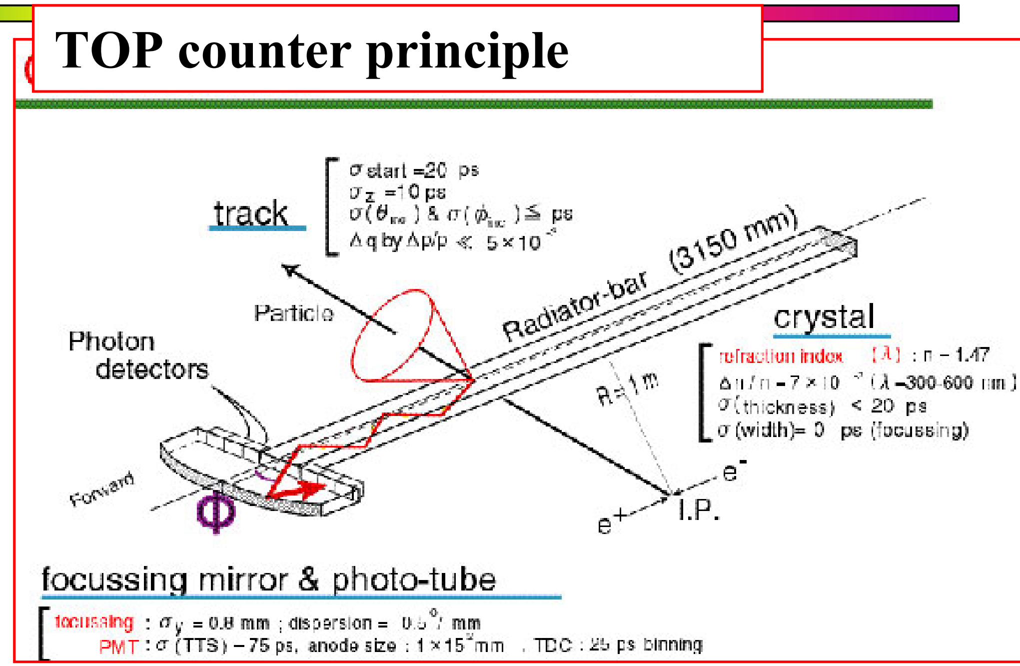


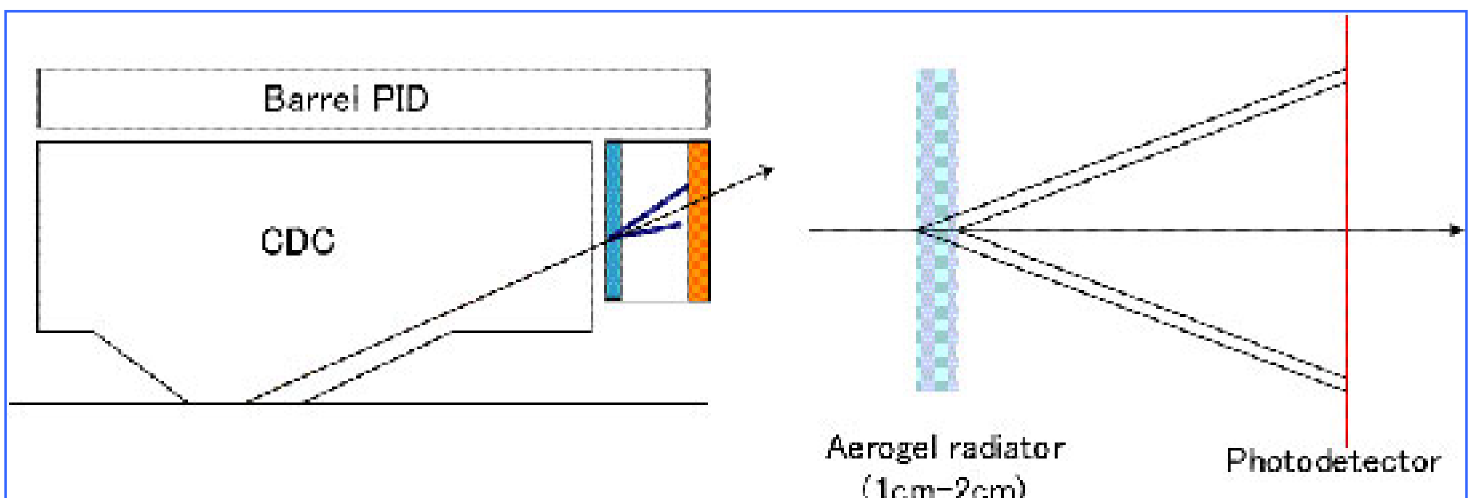
Typical configuration (rϕ view)



Particle Identification

- Ring imaging for improvement
- Two R&Ds ongoing
  - Time-of-Propagation (TOP) counter
  - Aerogel RICH (for endcap)



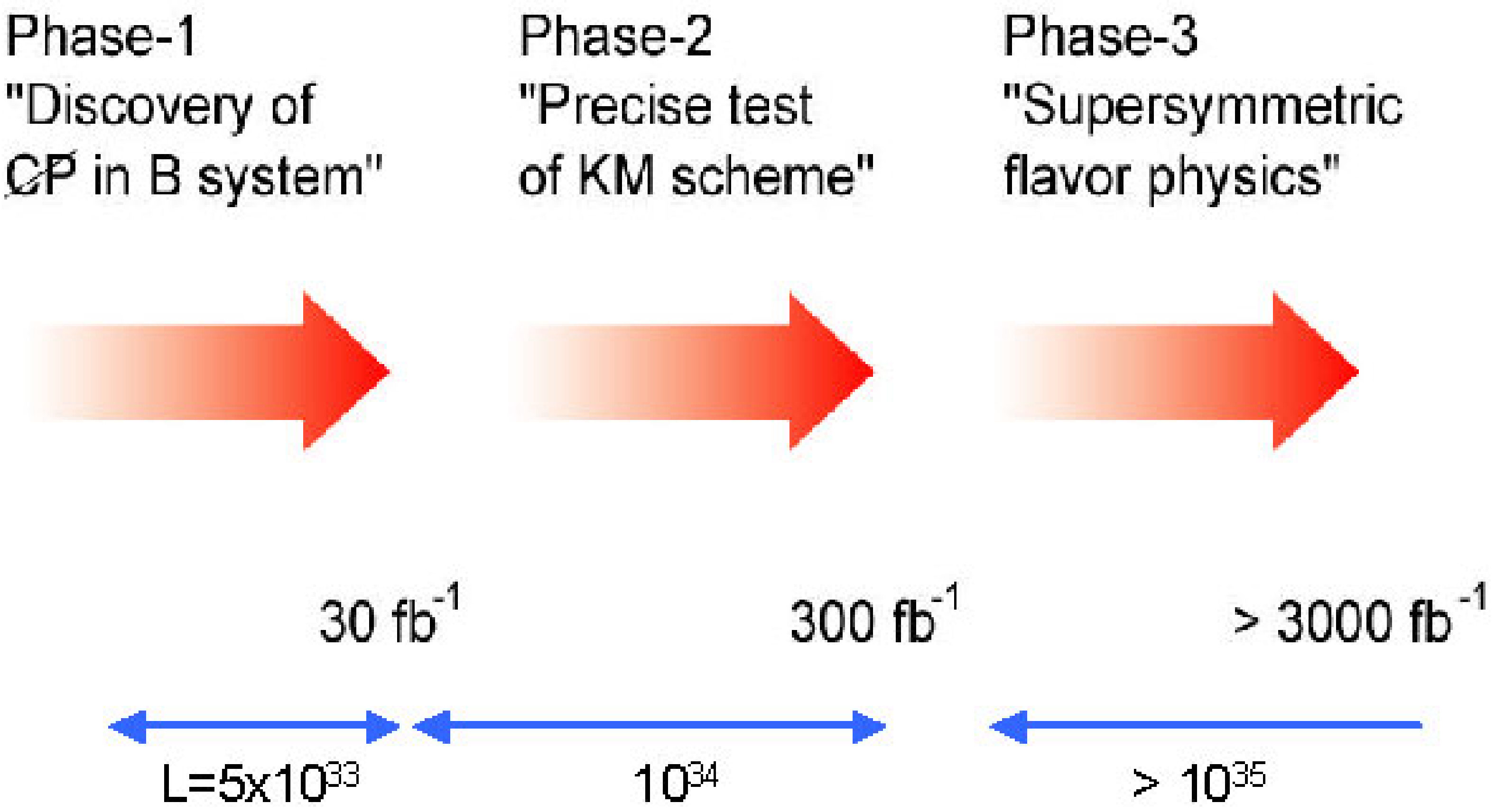


Summary

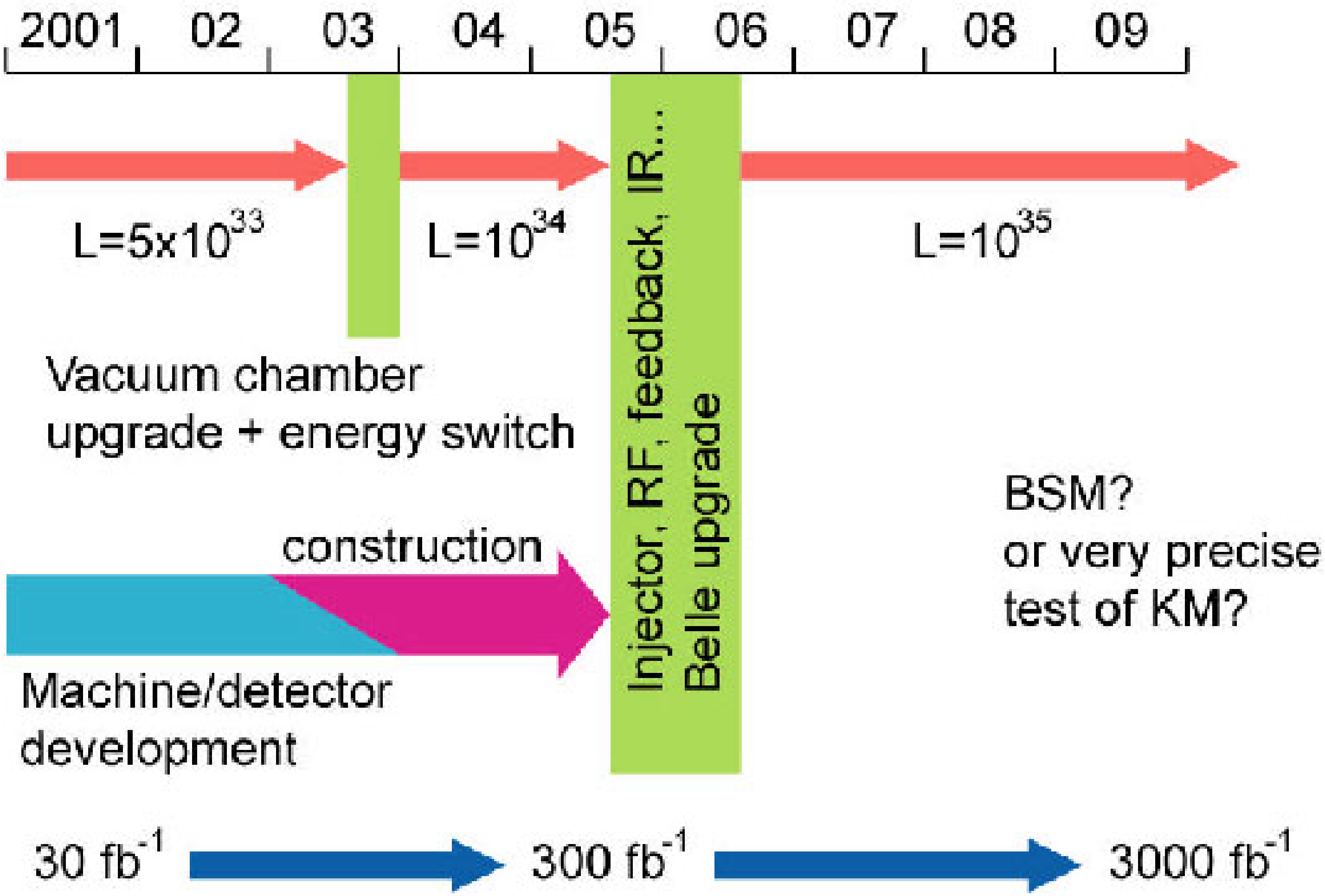
- Super KEKB is a major upgrade of the KEKB collider and the Belle detector.
- Target luminosity is 10^{35} $cm^{-2}s^{-1}$, which is quite feasible.
- Major upgrade in 2006. The experiment will start in a timely manner.
- 3 x 10^9 BB pairs (3000 fb^{-1}) with 3 years of data taking.
- Unique B physics programs to study "beyond the SM"
  - Flavor problem and CP problem
- Leading faciliy for charm and tau physics
- Precision for bread-and-butter CPV measurements comparable to hadron experiments.
- EoI preparation just finished. Design work has just started. Your participation is very very welcome.

Backup Slides

SUSY scenario

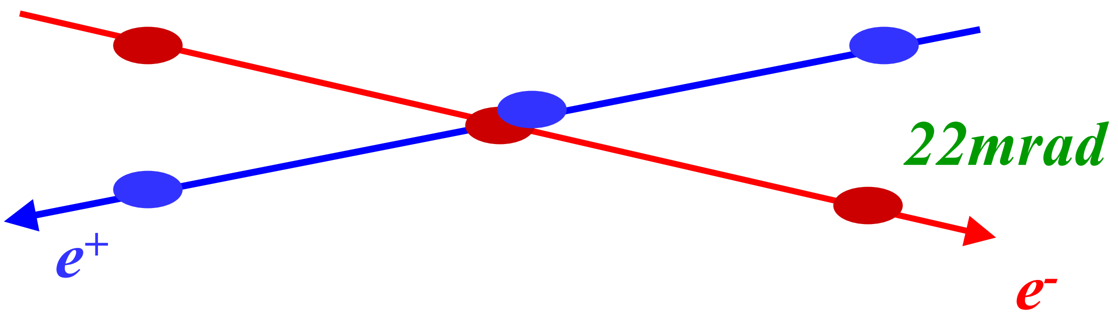


Schedule – an example



KEKB's Special Features

- Small beam sizes ⇒ low beam currents
  - 4.5×10^{33} with less than 1 Amp in each ring
- ± 11 mrad beam crossing angle



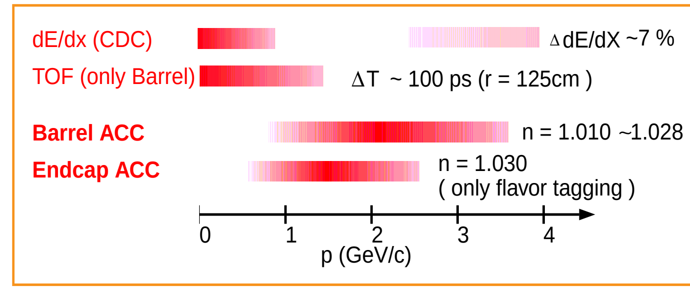
  - No strong bending magnets near the IR
  - Fewer spent particles into *Belle*
  - Synchrotron X-rays easily handled

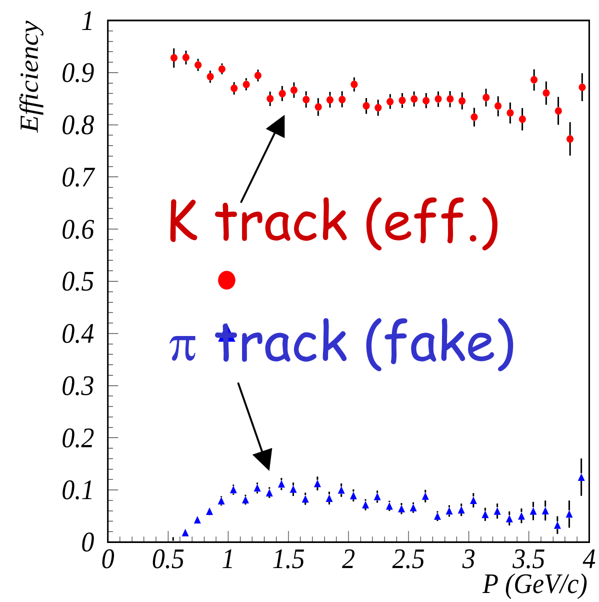
Particle Identification

- Clear K/π separation is essential to distinguish decays.
  - DK/Dπ
  - Kπ/ππ/KK etc.
  - K*γ/ργ
- Belle use dE/dx + ToF + ACC
  - Wide momentum coverage
  - ACC: Aerogel Cherenkov
  - Combined into likelihood;

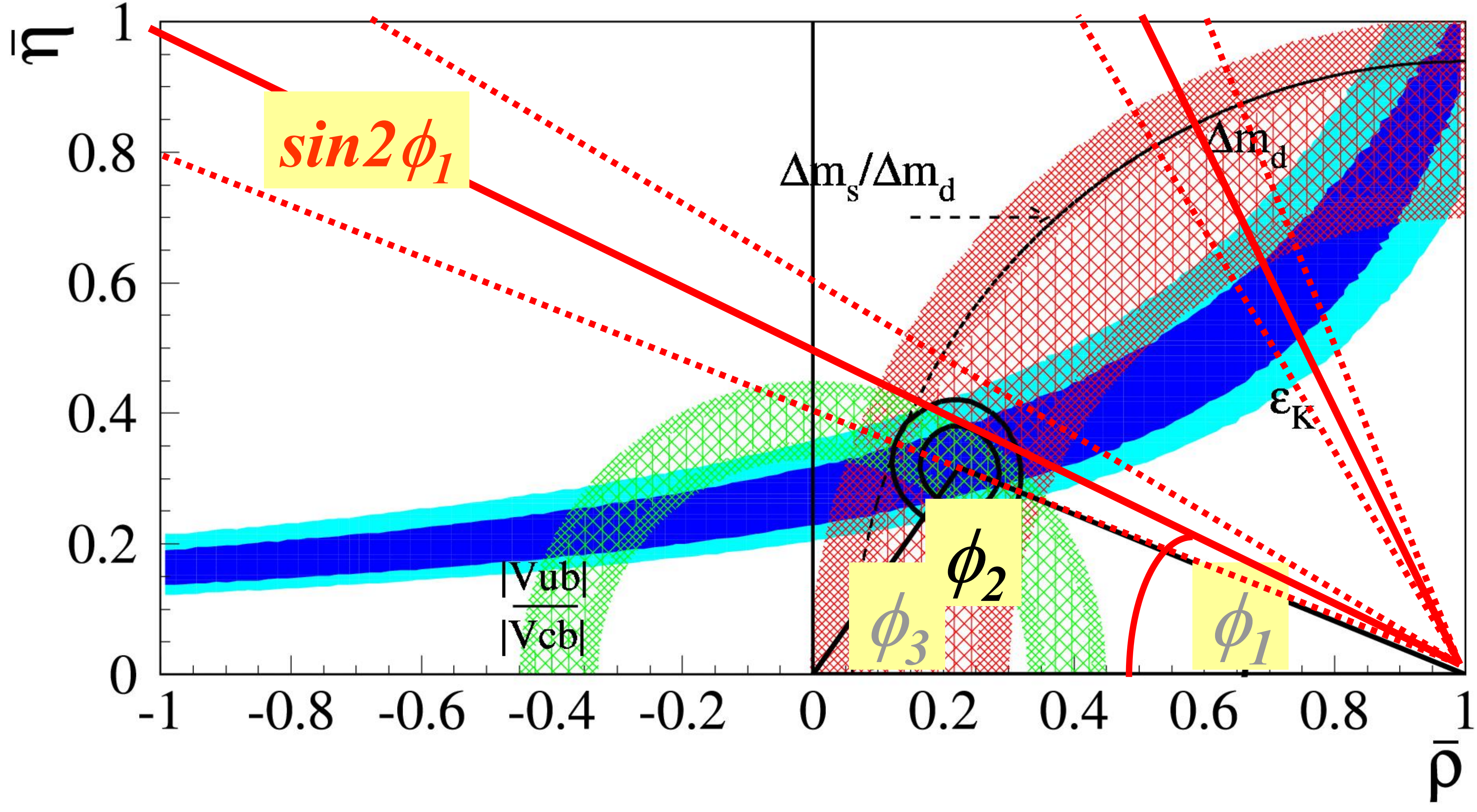
$$PID(K) = \frac{L(K)}{L(K)+L(\pi)}$$

~1 for K
~0 for π





- Calibration with $D^{*+} \rightarrow D^0\pi^+$, $D^0 \rightarrow K^-\pi^+$


$\bar{\eta}$
1
0.8
0.6
0.4
0.2
0
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
$\bar{\rho}$
$sin2\phi_1$
$\Delta m_s/\Delta m_d$
Δm_d
ε_K
$\frac{|V_{ub}|}{|V_{cb}|}$
ϕ_2
ϕ_3
ϕ_1

Towards $|V_{ub}|$: $B^0 \to \pi^- l^+ \nu$

Important to check large $\sin 2\phi_1$

update 21.3 fb^{-1}

$B^0 \to \pi^- l^+ \nu$

Missing mass recon.

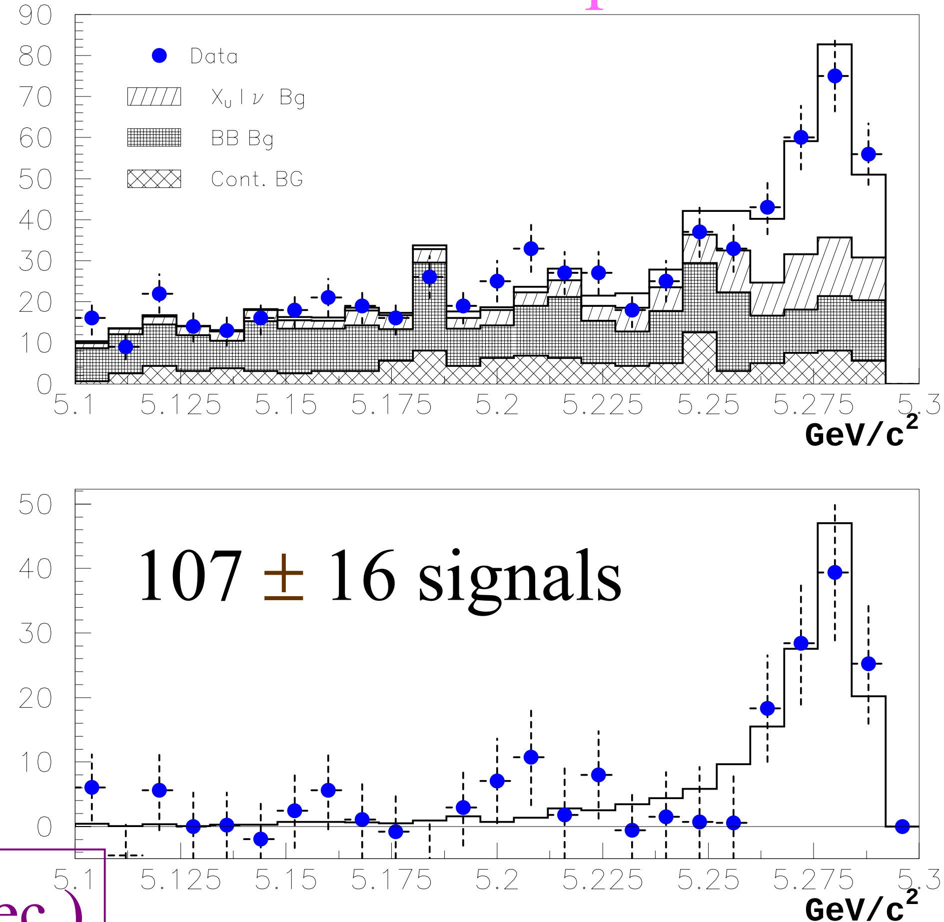
$$M_{miss}^2 = E_{miss}^2 - p_{miss}^2 < 2 \text{ GeV}$$

$p_l > 1.2$ GeV

$p_l + p_\pi > 3.1$ GeV

$Br = (1.28 \pm 0.2 \pm 0.26) \times 10^{-4}$

ε(trk/g rec.)



$b \to s$ Penguin $\Rightarrow \phi_1$ or ϕ_{NP} ?

Large Br for η'K, ηK* (found by CLEO): **confirmed**

$Br(B^0 \to \eta K^{*0}) = (21.2\ ^{+5.4}_{-4.7} \pm 2.0)\mathrm{x}10^{-6}$ 21.3 fb^{-1} (New)

$Br(B^+ \to \eta' K^+) = (79\ ^{+12}_{-11} \pm 9)\mathrm{x}10^{-6}$

$Br(B^0 \to \eta' K^0) = (55\ ^{+19}_{-16} \pm 8)\mathrm{x}10^{-6}$

10.4 fb^{-1} **[to PLB]**

Larger than theoretical expectation

$Br(B^+ \to \phi K^+) = (11.2\ ^{+2.2}_{-2.0} \pm 1.4)\mathrm{x}10^{-6}$

$Br(B^0 \to \phi K^0) = (8.9\ ^{+3.4}_{-2.7} \pm 1.0)\mathrm{x}10^{-6}$

21.3 fb^{-1} (update)

Time dependent CPV : ϕ_1 or New phase/Physics

New phases in b → s (d) penguins

M. Ciuchini, et al. “Gold-plated modes” are ***ϕ Ks*** and *η’Ks*

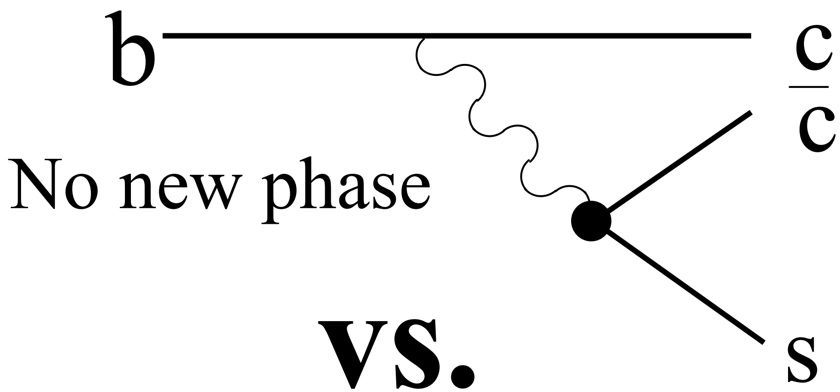
TABLE II. CP phases for B decays. $\phi^D_{\rm SM}$ denotes the decay phase in the SM; for each channel, when two amplitudes with different weak phases are present, one is given in the first row, the other in the last one, and the ratio of the two in the $r_{\rm SM}$ column. $\phi^D_{\rm SUSY}$ denotes the phase of the SUSY amplitude, and the ratio of the SUSY to SM contributions is given in the r_{250} and r_{500} columns for the corresponding SUSY masses.

Incl.	Excl.	$\phi^D_{\rm SM}$	$r_{\rm SM}$	$\phi^D_{\rm SUSY}$	r_{250}	r_{500}
$b \to c\bar{c}s$	$B \to J/\psi K_S$	0	–	ϕ_{23}	$0.03-0.1$	$0.008-0.04$
$b \to s\bar{s}s$	$B \to \phi K_S$	0	–	ϕ_{23}	$0.4-0.7$	$0.09-0.2$
$b \to u\bar{u}s$		Tree γ				
	$B \to \pi^0 K_S$		$0.009-0.08$	ϕ_{23}	$0.4-0.7$	$0.09-0.2$
$b \to d\bar{d}s$		Penguin 0				
$b \to c\bar{u}d$		0				
	$B \to D^0_{CP}\pi^0$		0.02	–	–	–
$b \to u\bar{c}d$		γ				
	$B \to D^+D^-$	Tree 0	$0.03-0.3$		$0.007-0.02$	$0.002-0.006$
$b \to c\bar{c}d$				ϕ_{13}		
	$B \to J/\psi\pi^0$	Penguin β	$0.04-0.3$		$0.007-0.03$	$0.002-0.008$
	$B \to \phi\pi^0$	Penguin β	–		$0.06-0.1$	$0.01-0.03$
$b \to s\bar{s}d$				ϕ_{13}		
	$B \to K^0\bar{K}^0$	u-Penguin γ	$0-0.07$		$0.08-0.2$	$0.02-0.06$
$b \to u\bar{u}d$	$B \to \pi^+\pi^-$	Tree γ	$0.09-0.9$	ϕ_{13}	$0.02-0.8$	$0.005-0.2$
$b \to d\bar{d}d$	$B \to \pi^0\pi^0$	Penguin β	$0.6-6$	ϕ_{13}	$0.06-0.4$	$0.02-0.1$
	$B \to K^+K^-$	Tree γ	$0.2-0.4$		$0.04-0.1$	$0.01-0.03$
$b\bar{d} \to q\bar{q}$				ϕ_{13}		
	$B \to D^0\bar{D}^0$	Penguin β	only β		$0.01-0.03$	$0.003-0.006$

CPV in b → s γ also important

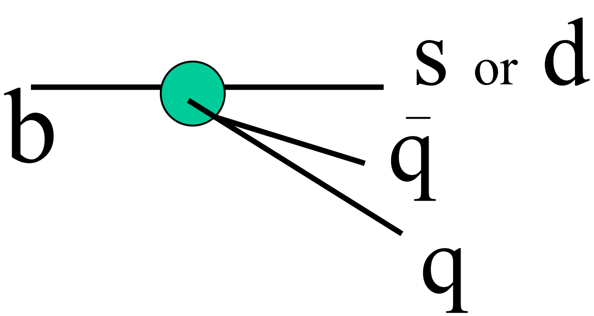
Clear Manifestation of New Physics !

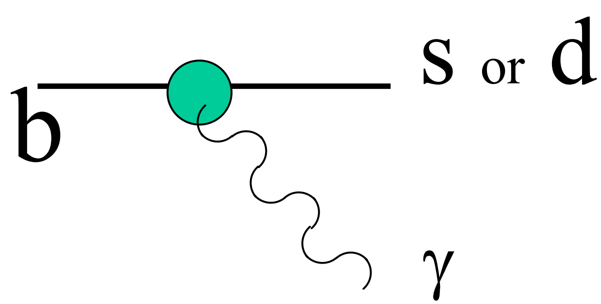
Acp(*J/ψ Ks*) ≠ Acp(Bcp with Penguin)



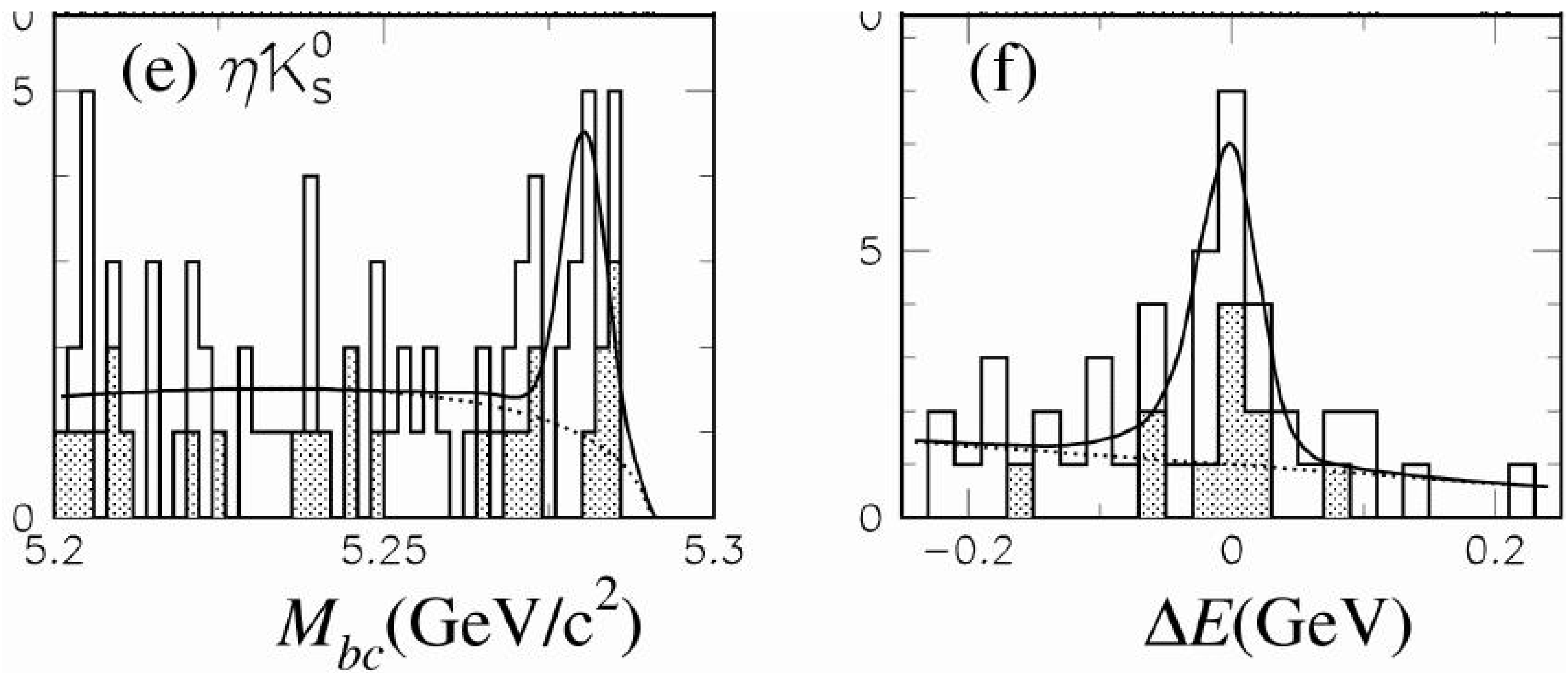
vs.

CP eigenstates (or flavor non-specific states) with any other decay diagrams, such as the following;





$B0 \rightarrow \eta' Ks$ (10.4fb^{-1})



Origin of the large branching fraction is not understood yet. It may include contribution from new physics !

$B^0 \to D^{*+}D^{(*)-} \Rightarrow \phi_1$

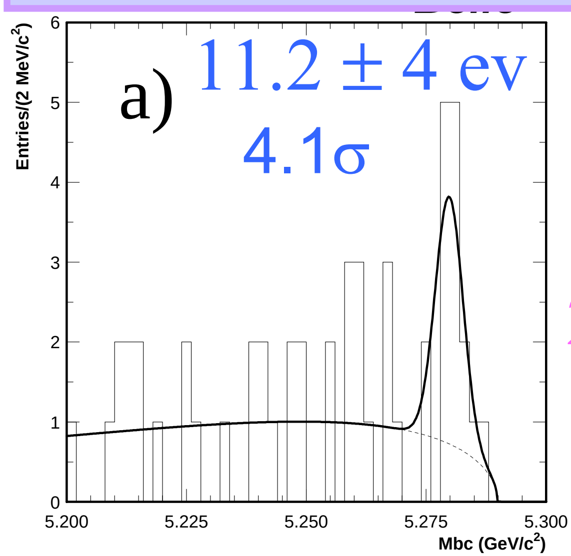
Full Reconstruction : better S/N

$B0 \to D^{*+}D^-$

Confirm partial Recon.

Br=1.04 ±0.38±0.22 (x10^{-3})

First Observation



21.3 fb^{-1}

(New)

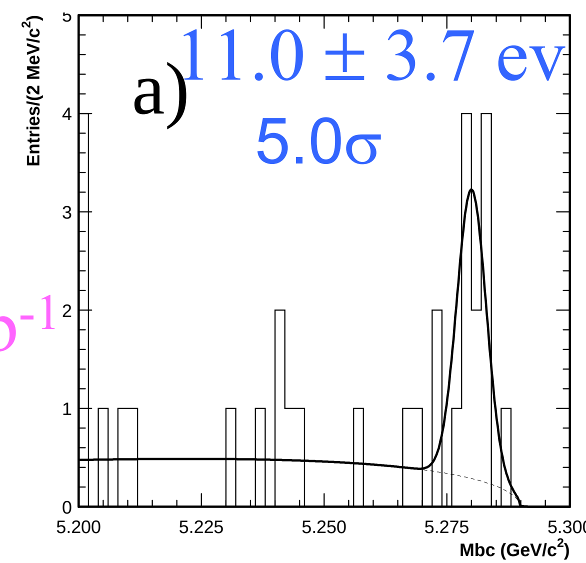
$B0 \to D^{*+}D^{*-}$

$D^{*+} \to D^0 \pi^+$ only

$\Rightarrow$ add $D^{*+} \to D^+ \pi^0$ mode

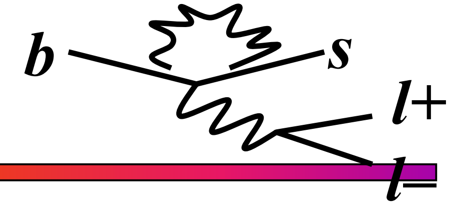
Need angular anal. for ϕ_1

Br=1.21 ±0.41±0.27 (x10^{-3})



$D^0 \to$
- $K^- \pi^+$
- $K^- \pi^+ \pi^0$
- $K^- \pi^+ \pi^+ \pi^-$

EW Penguin : $b \to s\, l^+ l^-$



Awaited mode sensitive to SUSY after $b \to s\gamma$ (consistent to SM)

Exclusive mode: $B \to K^{(*)} l^+ l^-$

x10^{-4}

$B \to K^* \mu^+ \mu^-$: < 3.0 ($2.8\,^{+2.9}_{-2.1}$)

$B \to K^* e^+ e^-$: < 5.1 ($5.5\,^{+3.7}_{-3.0}$)

$B \to K \mu^+ \mu^-$: $0.99\,^{+0.39}_{-0.32}\,^{+0.13}_{-0.15}$

$B \to K e^+ e^-$: < 1.2 ($2.6\,^{+2.7}_{-2.0}$)

First Observation

29.1 fb^{-1}

$B \to K^+ \mu^+ \mu^-$

$B \to Ks\, \mu^+ \mu^-$

combined