SuperKEKB/BelleII

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2nd Workshop on Beyond 3 Generation Standard Model

SuperKEKB Looks Promising

Subject: News from KEK

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Date: Thu, 7 Jan 2010 17:12:26 +0900

Dear colleagues,

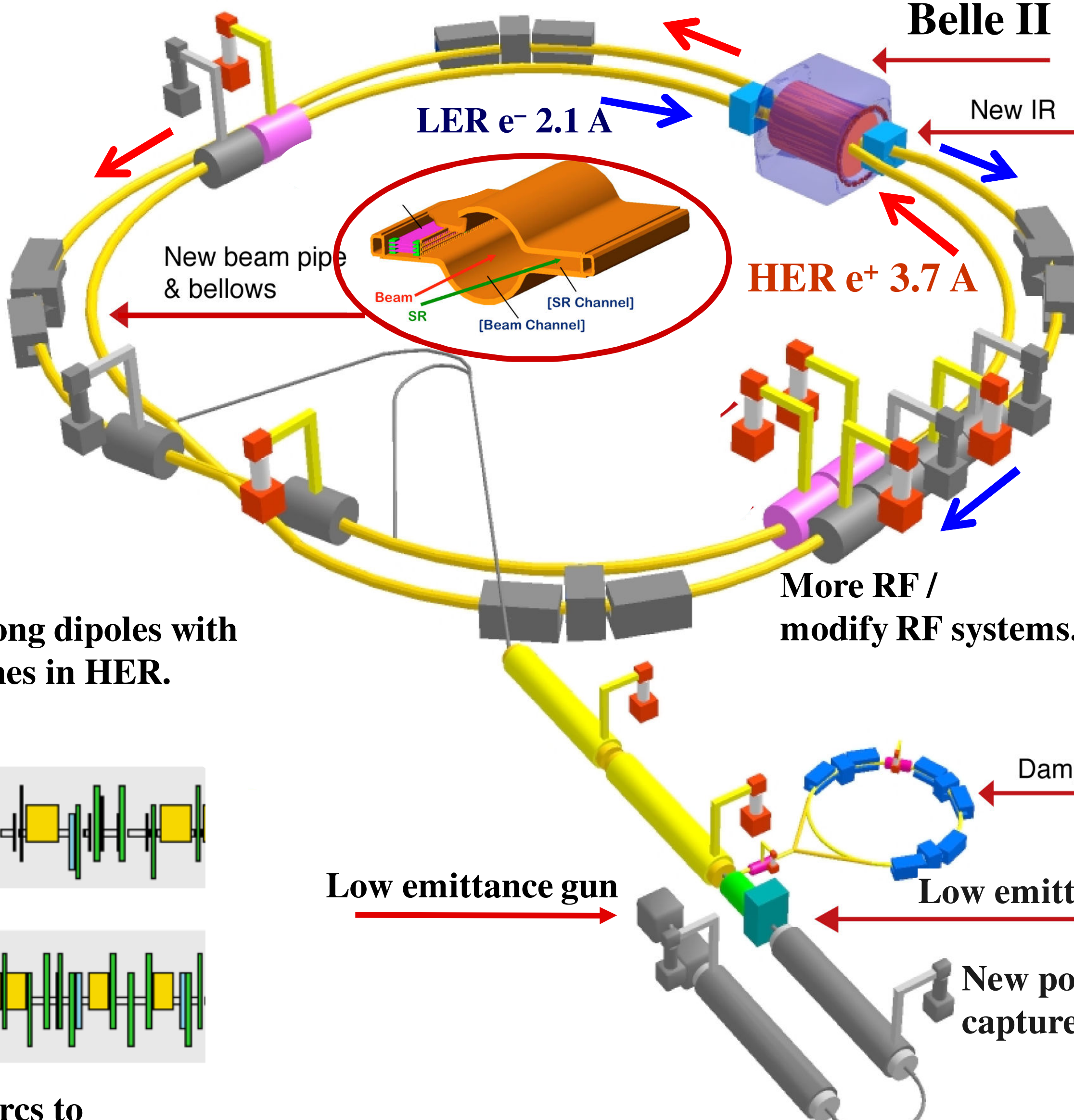
The Japanese Government has announced KEK's budget for JFY2010, in which preliminary approval was given to the KEKB upgrade program, and a budget was allocated to partially start construction. This does not yet constitute full approval of the overall project, but can be interpreted as a provisional decision by the Government in these difficult times of drastic change in the Japanese Government.

Happy 2010 to you all,

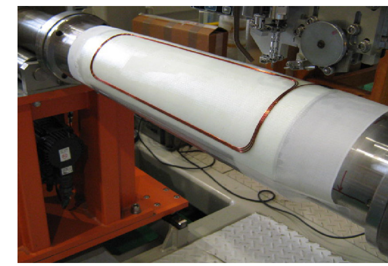
Masa Yamauchi

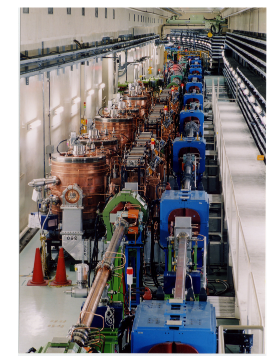
Running Belle/KEKB in 2010 is still under discussion, most likely for machine studies and runs other than $\Upsilon(4S)$.

KEKB upgrade → SuperKEKB(nano-beam)



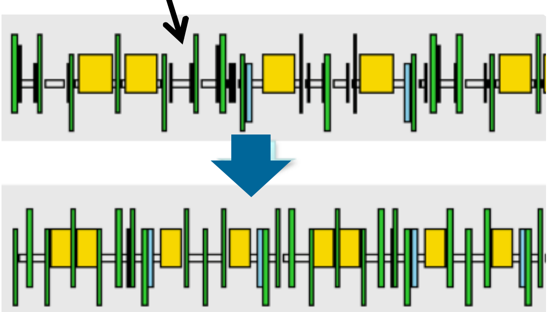
Two separate focusing quads/each 2 beams closer to IP; Superconducting / permanent magnets





More RF / modify RF systems.

Replace long dipoles with shorter ones in HER.



Redesign the HER arcs to reduce the emittance.

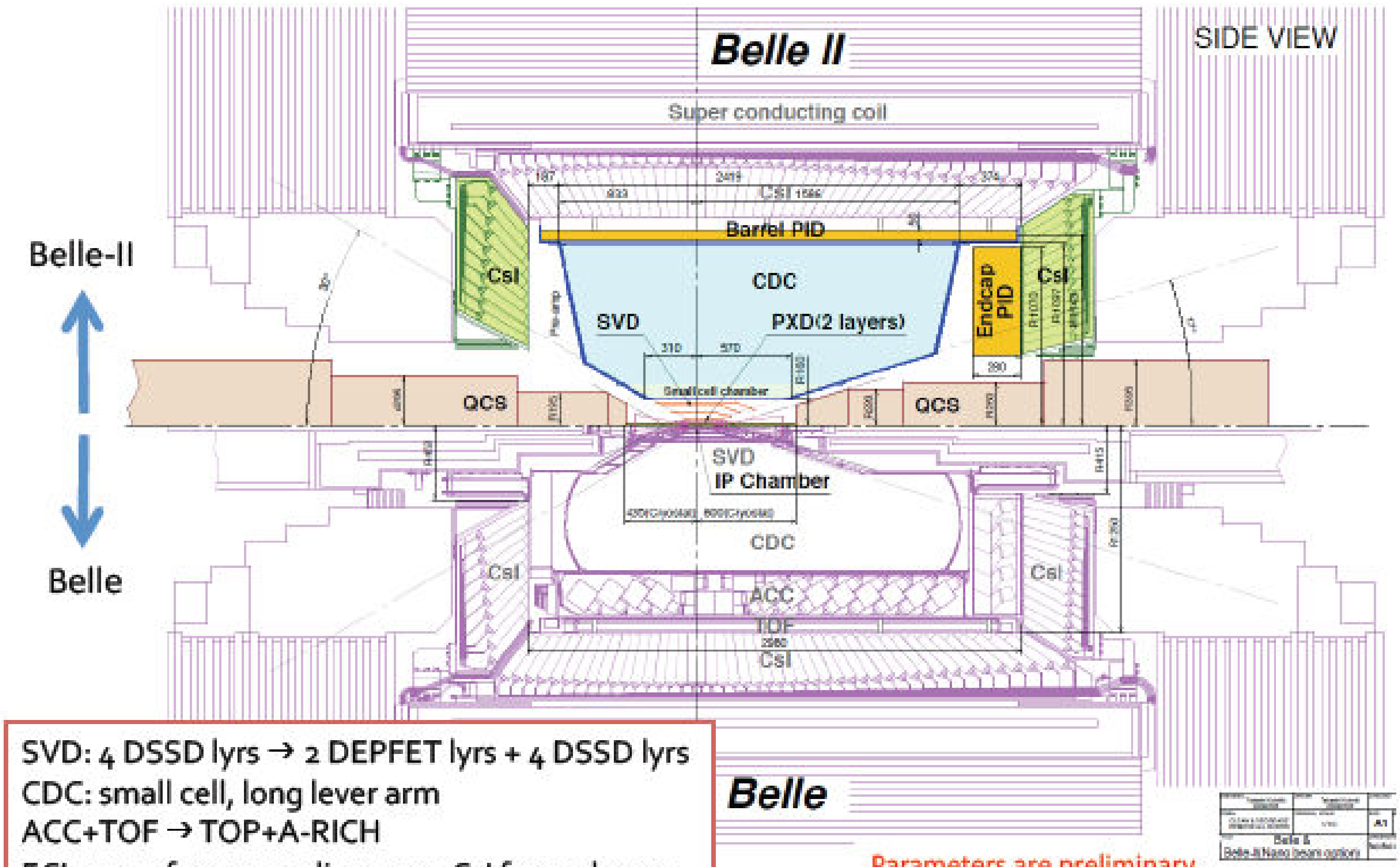
Low emittance gun

Low emittance positrons

New positron target / capture section

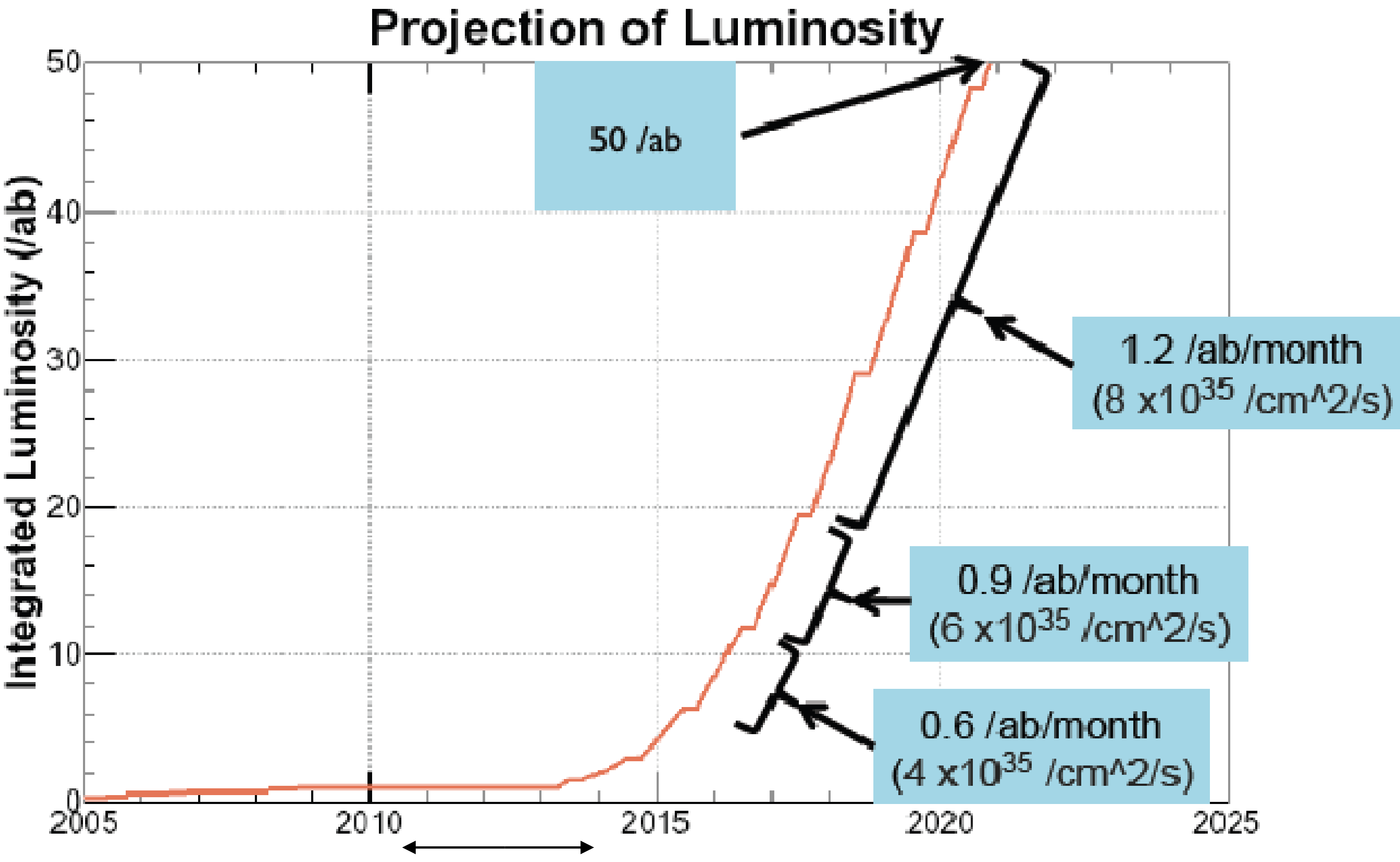
Target Luminosity: 8.0x10^{35} /cm^2/s

Belle II Detector



SVD: 4 DSSD lyrs → 2 DEPFET lyrs + 4 DSSD lyrs
CDC: small cell, long lever arm
ACC+TOF → TOP+A-RICH
ECL: waveform sampling, pure CsI for end-caps
KLM: RPC → Scintillator +SiPM (end-caps)

Luminosity projection



Shut down Belle
for upgrade

Belle-II Collaboration has been formed

2004.06 **SuperKEKB LoI**

2008.01 **KEK Roadmap**

2008.03 **1st Proto collaboration meeting**

2008.10 **Detector study report**

2008.12 **New collaboration, Belle-II, started**

~300 collaborators from 43 institutions in 13 countries

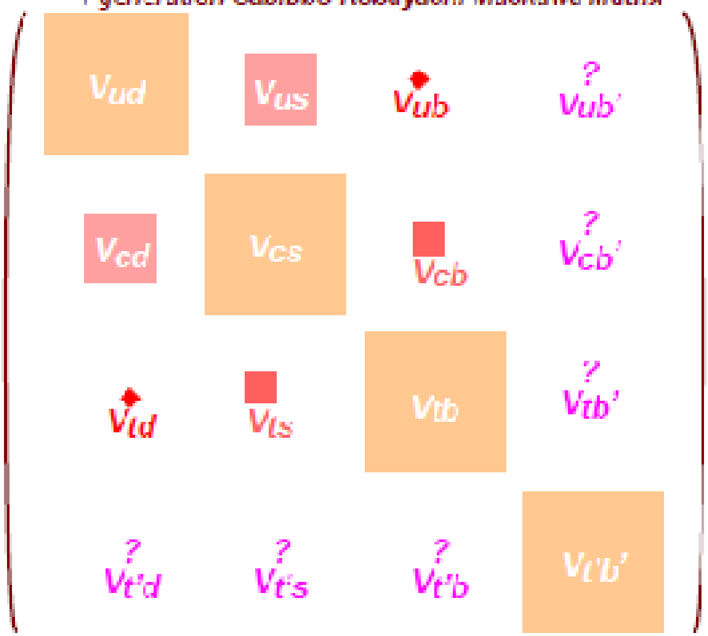
Peter Krizan (Ljubljana) elected as the first spokesperson

2009.11 **4th open collaboration meeting**

Task for This Forum

- How can super B factory pint down parameters of 4th generation assuming t' and b' are discovered at the LHC?
- $\Delta A(K\pi)$, A_{FB} of K*ll, D-$\overline{\text{D}}$ mixing, …

4 generation Cabibbo-Kobayashi-Maskawa Matrix



V_{ub} and V_{cb}

Directly measured
matrix elements
including W-decays

$$\begin{pmatrix} 0.97418 & 0.2253 & 0.0043 & <0.046 \\ 0.224 & 0.973 & 0.041 & <0.20 \\ <0.045 & <0.125 & >0.78 & <0.63 \\ <0.075 & <0.21 & <0.63 & >0.78 \end{pmatrix}$$

↑

See H. Lacker's talk

- **Estimation given by the two groups**
- **Theoretically limited**
- **Tension between Vub inclusive and exclusive**

	SuperKEKB		SuperB	
Mode	5 ab^{-1}	50 ab^{-1}	2 ab^{-1}	75 ab^{-1}
$\lvert V_{cb}\rvert$ (inclusive)			1%	0.5%
$\lvert V_{cb}\rvert$ (exclusive)			4%	1.0%
$\lvert V_{ub}\rvert$ (inclusive)	5%	3%	8%	2.0%
$\lvert V_{ub}\rvert$ (exclusive)	12%	5%	8%	3.0%

UT angle ϕ_1/β H. Lacker

Complications with 4th generation:

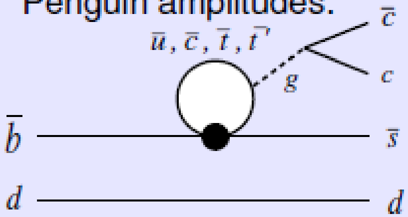
1) K-$\overline{\text{K}}$ mixing => $\sin(2\beta-2\theta_d)\rightarrow\sin(2\beta-2\theta_d+2\delta_1)$ mit $\delta_1=Arg\left(\frac{V_{ud}V_{us}^*}{V_{cd}V_{cs}^*}\right)+\pi$

Experimental precision on "β" of 1° ~ constraint on δ_1 !

- Weak phases of t- & t'-penguin = weak phase of c-penguin?
- Current 4th generation constraints: $|V_{cs}V_{cb}^*| << |V_{ts}V_{tb}^*|, |V_{t's}V_{t'b}^*|$

=> q/p not any more pure phase => decay amplitudes & phases to be included or to be constrained using J/ψ h decays?

Penguin amplitudes:



$V_{cs}V_{cb}^*P_{cu}$

$V_{ts}V_{tb}^*P_{tu}$

$V_{t's}V_{t'b}^*P_{t'u}$

	SuperKEKB		SuperB	
Mode	5 ab^{-1}	50 ab^{-1}	2 ab^{-1}	75 ab^{-1}
$\sin 2\phi_1/\sin 2\beta$	0.016	0.012	0.018	0.005
$\Delta S_{\phi K^0}$	0.073	0.029	0.13	0.02
$\Delta S_{\eta' K^0}$	0.038	0.020	0.05	0.01
$\Delta S_{K_S^0 K_S^0 K_S^0}$	0.105	0.037	0.15	0.02

UT angle ϕ_2/α

- **Is it really an independent measurement without assuming the close triangle?**
- **Isospin violation: O(1.5°)**

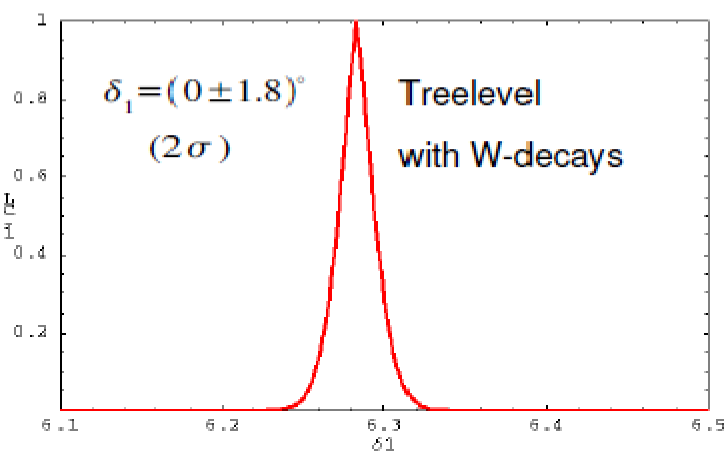
P_{EW} with 4th generation could be much larger: $\frac{P_{EW}}{T^{+0}} \approx \frac{3}{2}\left[\frac{V_{td}V_{tb}^{*}}{V_{ud}V_{ub}^{*}}\,\frac{C_9^{t}+C_{10}^{t}}{C'_1+C'_2}+\frac{V_{t'd}V_{t'b}^{*}}{V_{ud}V_{ub}^{*}}\,\frac{C_9^{t'}+C_{10}^{t'}}{C'_1+C'_2}\right]$

	SuperKEKB		SuperB	
Mode	5 ab^{-1}	50 ab^{-1}	2 ab^{-1}	75 ab^{-1}
$\phi_2(\alpha)(\pi\pi)$	10°	3°	$\sim 16^\circ$	3°
$\phi_2(\alpha)(\rho\rho)$	3°	1°	$\sim 7^\circ$	$1-2^\circ$
$\phi_2(\alpha)(\rho\pi)$	3°	1°	$\sim 12^\circ$	3°
$\phi_2(\alpha)$(combined)	2°	1°	$\sim 6^\circ$	$1-2^\circ$

UT angle ϕ_3/γ

$\gamma = Arg\left(-\frac{V_{ud}V_{ub}^*}{V_{cd}V_{cb}^*}\right)$ but the following CKM element combinations appear in

weak decay or
also K-$\bar{K}$ mixing



	SuperKEKB		SuperB	
Mode	5 ab^{-1}	50 ab^{-1}	2 ab^{-1}	75 ab^{-1}
$\phi_3(\gamma)$ (Dalitz)	7°	2.5°	9°	1.5°
$\phi_3(\gamma)$ (ADS)			12°	2.0°
$\phi_3(\gamma)$ (GLW)			15°	2.5°
$\phi_3(\gamma)$ (ADS+GLW)	16°	5°		
$\phi_3(\gamma)$ ($D^{(*)}\pi$)	18°	6°	20°	5°
$\phi_3(\gamma)$ (combined)	6°	2°	6°	1 − 2°

Other channels

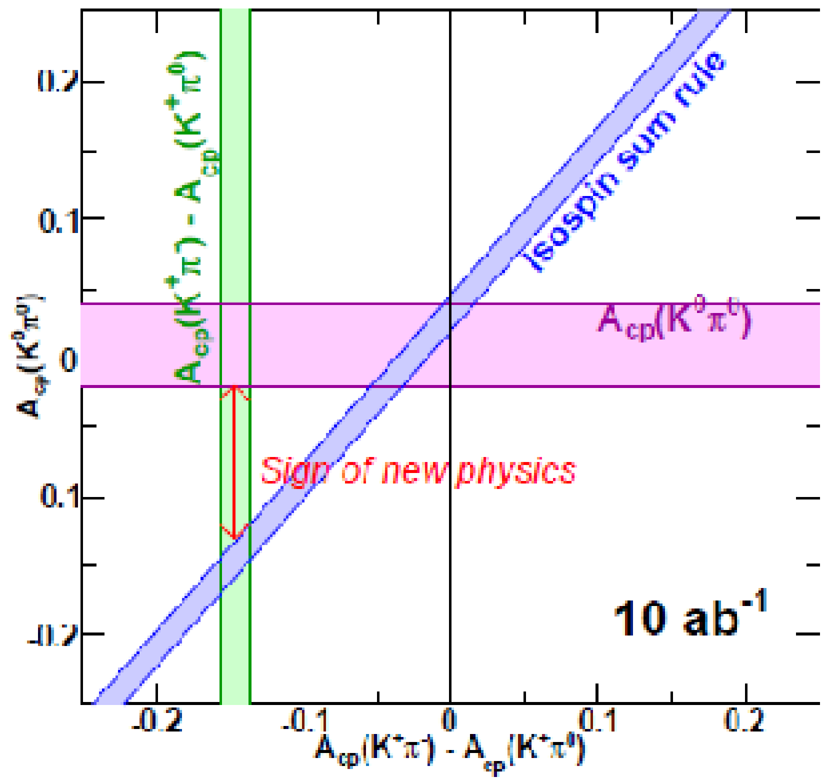
Mode	SuperKEKB 5 ab^{-1}	SuperKEKB 50 ab^{-1}	SuperB 2 ab^{-1}	SuperB 75 ab^{-1}
$\mathcal{B}(B \to X_s \gamma)$	7%	6%		
$A_{CP}(B \to X_s \gamma)$	0.01	0.005	0.012	0.004
$\mathcal{B}(B \to \tau\nu)$	10%	3%	20%	4%
$\mathcal{B}(B \to \mu\nu)$			visible	5%
$\mathcal{B}(B^+ \to D\tau\nu)$	7.9%	2.5%		
$\mathcal{B}(B^0 \to D\tau\nu)$	28.5%	9.0%		
$\mathcal{B}(B \to D\tau\nu)$			10%	2%
C_9 from $A_{\rm FB}(B \to K^* \ell^+ \ell^-)$	11%	4%		
C_{10} from $\overline{A}_{\rm FB}(B \to K^* \ell^+ \ell^-)$	13%	4%		
C_7/C_9 from $\overline{A}_{\rm FB}(B \to K^* \ell^+ \ell^-)$		5%		
$A_{CP}(B \to K^* \ell\ell)$			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%

Kπ Puzzle

H. Lacker, M. Nakao

$$A_{CP}(K_S\pi^0)\frac{2BF(K^0\pi^0)}{BF(K^+\pi^-)}\frac{\tau_0}{\tau_+}=A_{CP}(K^+\pi^-)-A_{CP}(K^+\pi^0)\frac{2BF(K^+\pi^0)}{BF(K^+\pi^-)}\frac{\tau_0}{\tau_+}+A_{CP}(K^0\pi^+)\frac{BF(K^0\pi^+)}{BF(K^+\pi^-)}\frac{\tau_0}{\tau_+}$$

	5 ab^{-1}	**50 ab^{-1}**
$A(K^0\pi^0)$	**0.072**	**0.042**



D mixing SuperKEKB

	$(\sim 0.5\ \text{ab}^{-1})^{\ddagger}$	$(5\ \text{ab}^{-1})$	$(50\ \text{ab}^{-1})$
Charm physics			
D mixing parameters			
x	0.25%	0.10%	0.07%
y	0.18%	0.08%	0.05%
$\delta_{K\pi}$	11°	6°	4°
$\lvert q/p \rvert$	0.16	0.07	0.05
ϕ	0.13 rad	0.07 rad	0.04 rad
A_D	2.4%	1%	0.3%
New particles			

Bs Physics SuperB

Observable	Error with 1 ab^{-1}	Error with 30 ab^{-1}
$\Delta\Gamma$	0.16 ps^{-1}	0.03 ps^{-1}
Γ	0.07 ps^{-1}	0.01 ps^{-1}
β_s from angular analysis	20°	8°
A^s_{SL}	0.006	0.004
A_{CH}	0.004	0.004
$\mathcal{B}(B_s \to \mu^+\mu^-)$	-	$< 8 \times 10^{-9}$
$\|V_{td}/V_{ts}\|$	0.08	0.017
$\mathcal{B}(B_s \to \gamma\gamma)$	38%	7%
β_s from $J/\psi\phi$	10°	3°
β_s from $B_s \to K^0\bar{K}^0$	24°	11°

LFV in τ decays

Observable	Belle 2006 ($\sim$0.5 ab^{-1})	SuperKEKB (5 ab^{-1})	SuperKEKB (50 ab^{-1})
$\mathcal{B}(\tau \to \mu\gamma)$ $[10^{-9}]$	< 45	< 30	< 8
$\mathcal{B}(\tau \to \mu\eta)$ $[10^{-9}]$	< 65	< 20	< 4
$\mathcal{B}(\tau \to \mu\mu\mu)$ $[10^{-9}]$	< 209	< 10	< 1

Back Up

Comparison of parameters

Low Energy ring / High Energy ring	KEKB design	KEKB achieved (with crab)	SuperKEKB High-Current	SuperKEKB Nano-Beam
β_y^* (mm)	10 / 10	6.5 / 5.9 (5.9 / 5.9)	3 / 6	0.26 / 0.26
ε_x (nm)	18 / 18	18(15) / 24	24 / 18	2.8 / 2.0
σ_y(μm)	1.9	1.1	0.85 / 0.73	0.084 / 0.072
ξ_y	0.052	0.108 / 0.056 (0.101 / 0.096)	0.3 / 0.51	0.08 / 0.08
σ_z (mm)	4	~ 7	5 / 3	5 / 5
I_{beam} (A)	2.6 / 1.1	1.8 / 1.45 (1.62 / 1.15)	9.4 / 4.1	3.6 / 2.1
$N_{bunches}$	5000	~ 1500	5000	~ 2000
Luminosity (10^{34} cm^{-2} s^{-1})	1	1.76 (2.08)	53	80

Preliminary

Also consider smaller boost: E_{HER}/E_{LER} KEKB 8GeV/3.5GeV → SuperKEKB 7GeV/4GeV easier for accelerator people; not very critical for physics

Beam parameters

	KEKB Design	KEKB Achieved : with crab	SuperKEKB High-Current	SuperKEKB Nano-Beam
Energy (GeV) (LER/HER)	3.5/8.0	3.5/8.0	3.5/8.0	4.0/7.0
β_y^* (mm)	10/10	5.9/5.9	3/6	0.27/0.42
ε_x (nm)	18/18	18/24	24/18	3.2/1.7
σ_y(μm)	1.9	0.94	0.85/0.73	0.059
ξ_y	0.052	0.129/0.090	0.3/0.51	0.09/0.09
σ_z (mm)	4	~ 6	5/3	6/5
I_{beam} (A)	2.6/1.1	1.64/1.19	9.4/4.1	3.6/2.6
$N_{bunches}$	5000	1584	5000	2500
Luminosity (10^{34} cm^{-2} s^{-1})	1	2.11	53	80

x40

Detector upgrade

Critical issues at L = 8×10^{35}/cm^2/sec

- **Higher event rate**
  - higher rate trigger, DAQ and computing
- **Higher background**
  - radiation damage and occupancies
  - fake hits and pile-up noise in the ECL

\+

- **Improve performance**
  - try better PID options
  - low p μ identification for b → sμμ efficiency
  - hermeticity → missing E "reconstruction"