Search for BSM with L>10^{35} KEKB

素核研 •研究計画委員会

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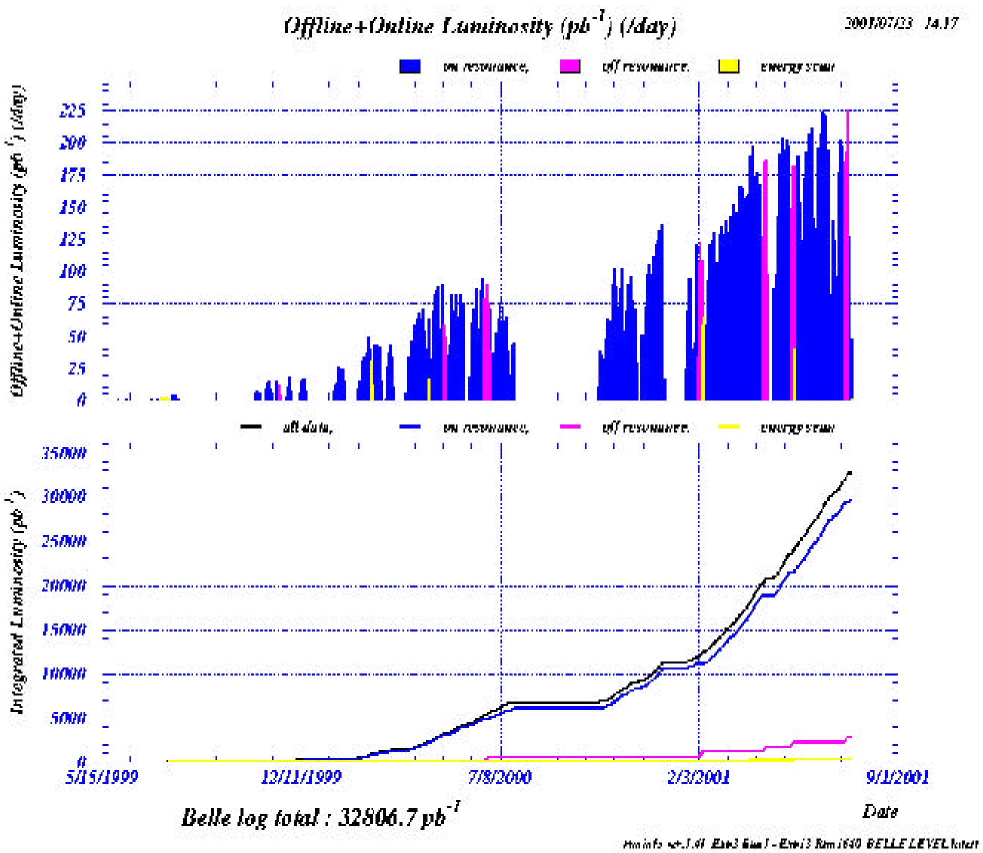
KEK－ IPNS

Outline

- Introduction – where we are
- Approaches to BSM in ***B*** decays
  - Effects on rare *B* decays
  - Effects on τ decays
- Accelerator design
- Detector design
- Schedule
- Summary

KEKB luminosity



L_{peak}=5.4x10^{33}/cm^2/s
(World record)

Max L_{day} = 280pb^{-1}

Total integ. L = 32.8fb^{-1}
(before summer 01)

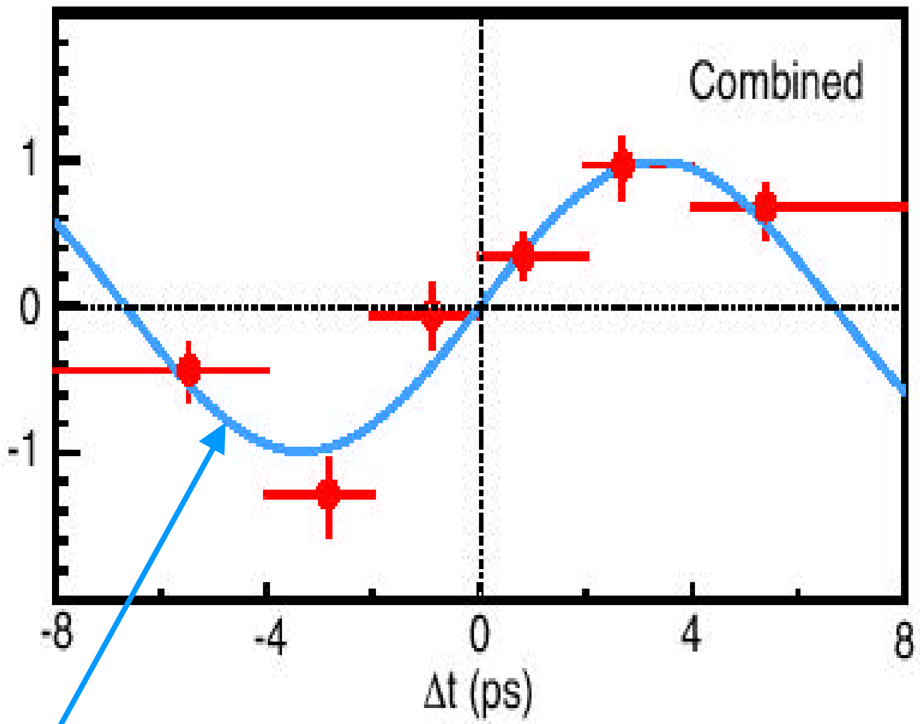
CP violation in $B^0\overline{B}^0$ system

$$A_{CP}(t)=\frac{\Gamma(\overline{B}^0\rightarrow J/yK_S;t)-\Gamma(B^0\rightarrow J/yK_S;t)}{\Gamma(\overline{B}^0\rightarrow J/yK_S;t)+\Gamma(B^0\rightarrow J/yK_S;t)}$$
$$=\sin 2f_1 \sin \Delta mt$$

↓

CP asymmetry

and meas. of ϕ_1.



Result from global fit ($\sin2f_1$=0.99)

Three phases of KEKB

Phase-1
"Discovery of
$\not{CP}$ in B system"

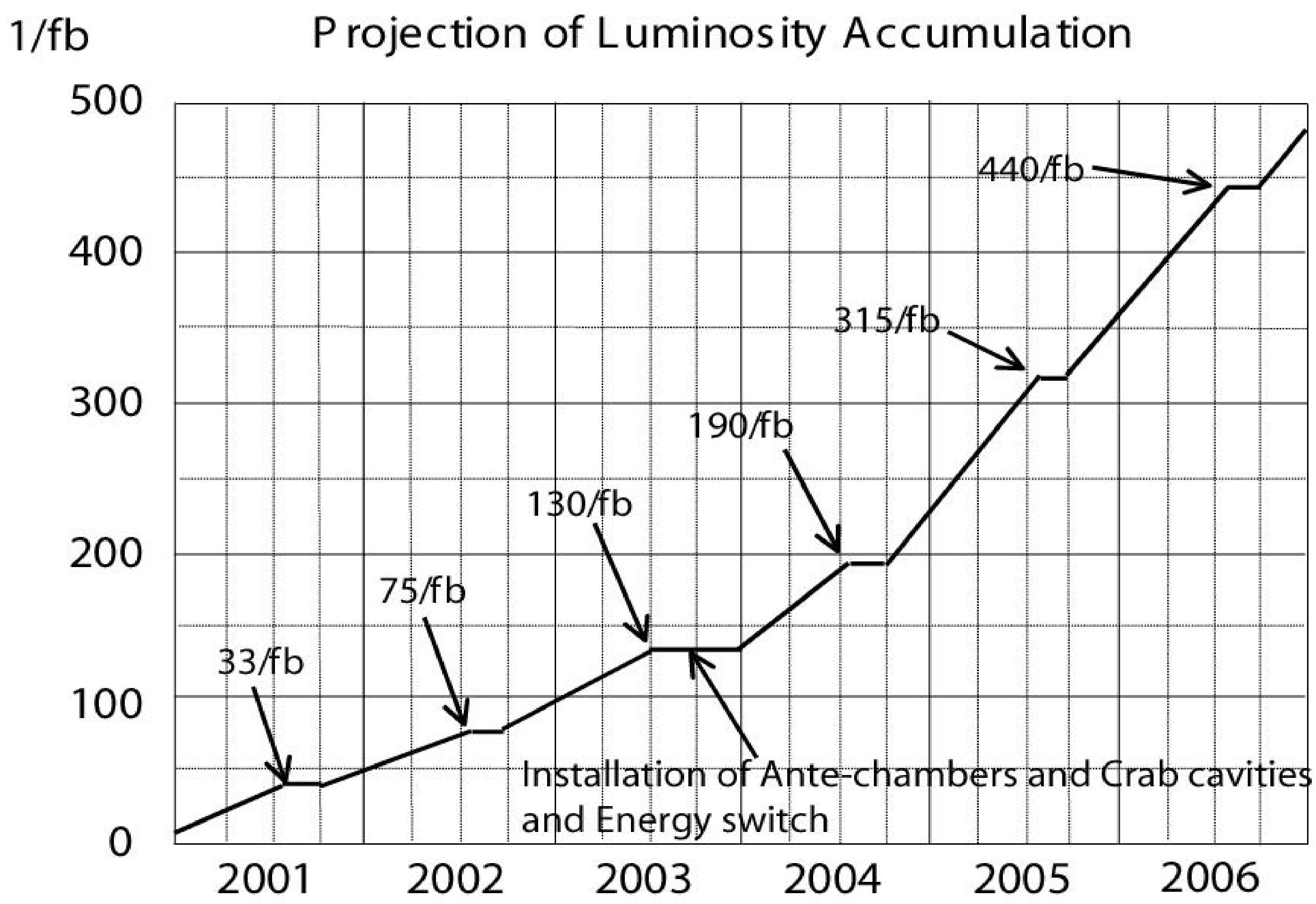
Phase-2
"Precise test
of KM scheme"

Phase-3
"Supersymmetric
flavor physics"

30 fb^{-1} | 300 fb^{-1} | > 3000 fb^{-1}

$L=5\times10^{33}$ | 10^{34} | $> 10^{35}$

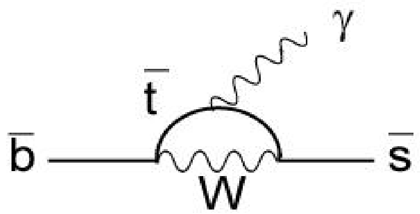
KEKB in near future



The triangle in 2006

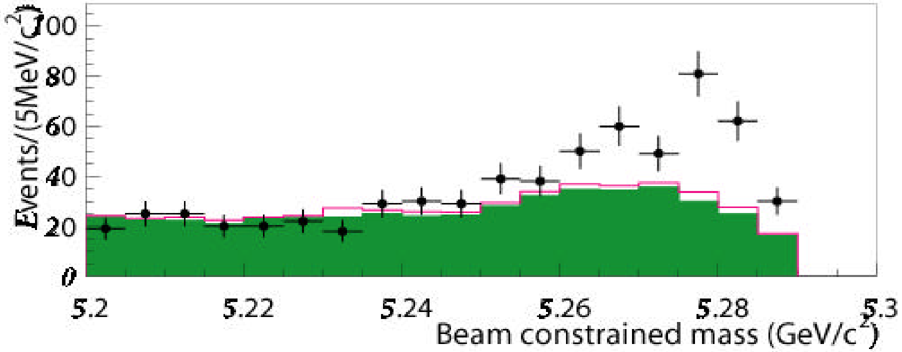
Element	Method	Meas. err. w/300fb^{-1}
$\|V_{cb}\|$	$B\to D^{(*)}l\nu$	10%
$\|V_{ub}\|$	$B\to X_u l\nu$	15%
$\|V_{td}\|$	Δm, $B\to\rho\gamma$	5%, if f_B is determined
ϕ_1	$J/\psi Ks$ etc.	1.5deg.
ϕ_2	$B\to\pi\pi$, $\rho\pi$	δA_{CP}=20%
ϕ_3	$B\to K\pi,\pi\pi$	δA_{CP}=3%
	$B\to D_{CP}K$	δA_{CP}=10%
$\phi_1+\phi_2+\phi_3$		13deg.

SUSY in EW penguin (1)



+ H^+ , SUSY particles??

- Dataset
  5.3 million $B\bar{B}$
- Signal yield
  106.5 ± 16.8 events



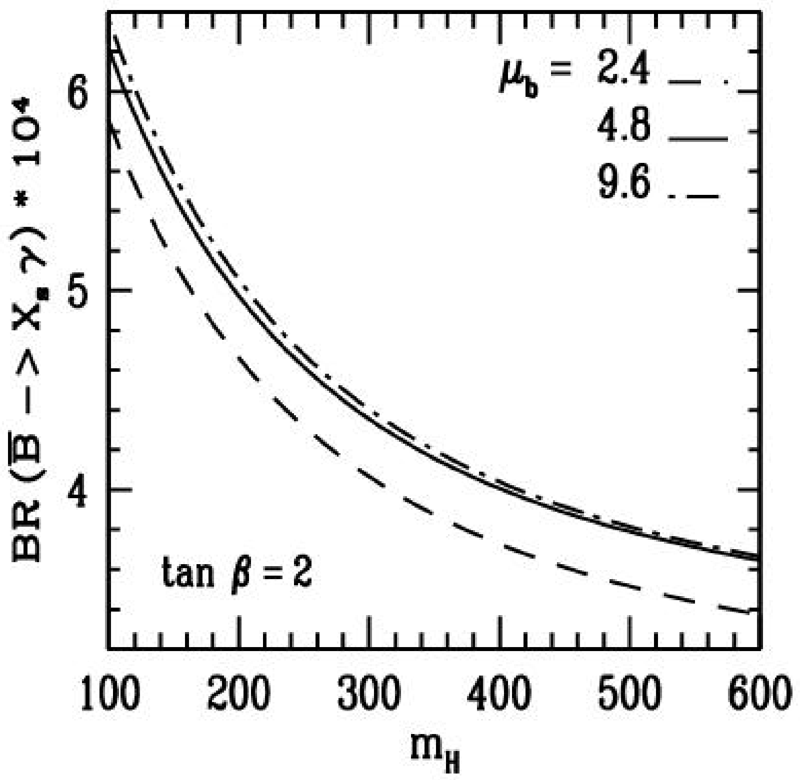
$$Br(B \rightarrow X_s \gamma) = (3.36 \pm 0.53(stat) \pm 0.42(sys)^{+0.50}_{-0.54}(th)) \times 10^{-4}$$

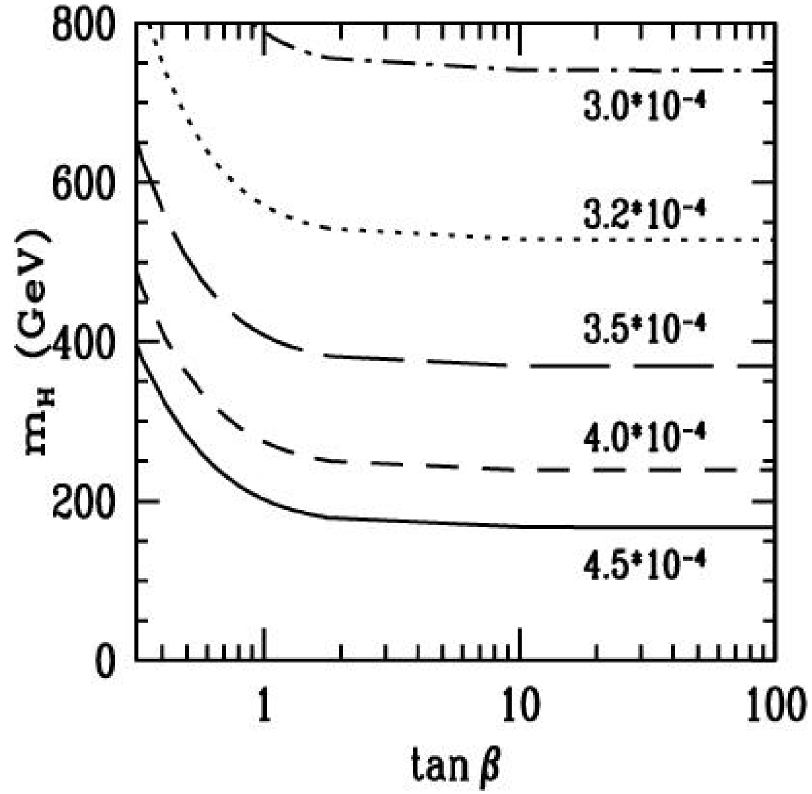
[PL B511, 151 (2001)]

↔ SM: Br = ~3×10^{-4} with 10% uncertainty
Acp = 0.5%
(to be measured with 1% error
with $1000 fb^{-1}$.)

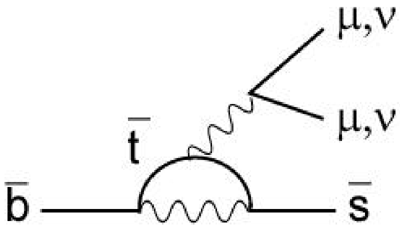
$B \to X_s g$ and $H^{+/-}$

Borzumati and Greub

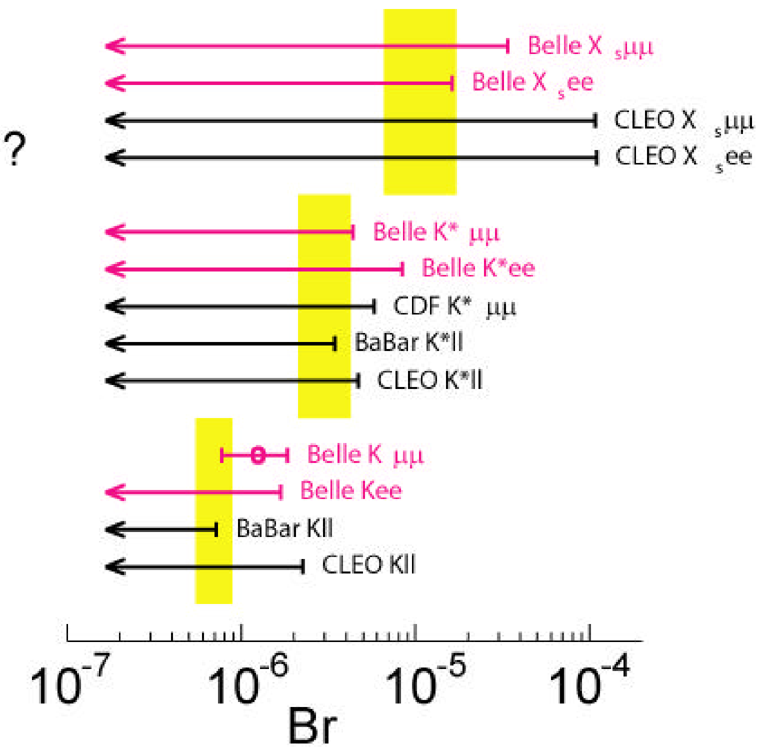




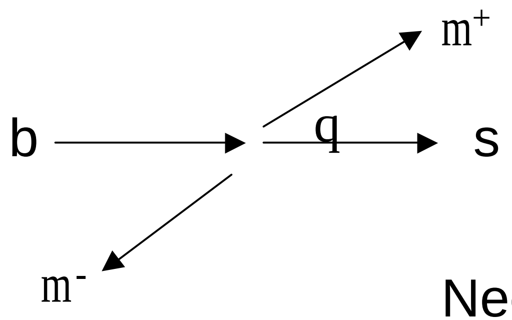
SUSY in EW penguin (2)



+ H^+ , SUSY particles??



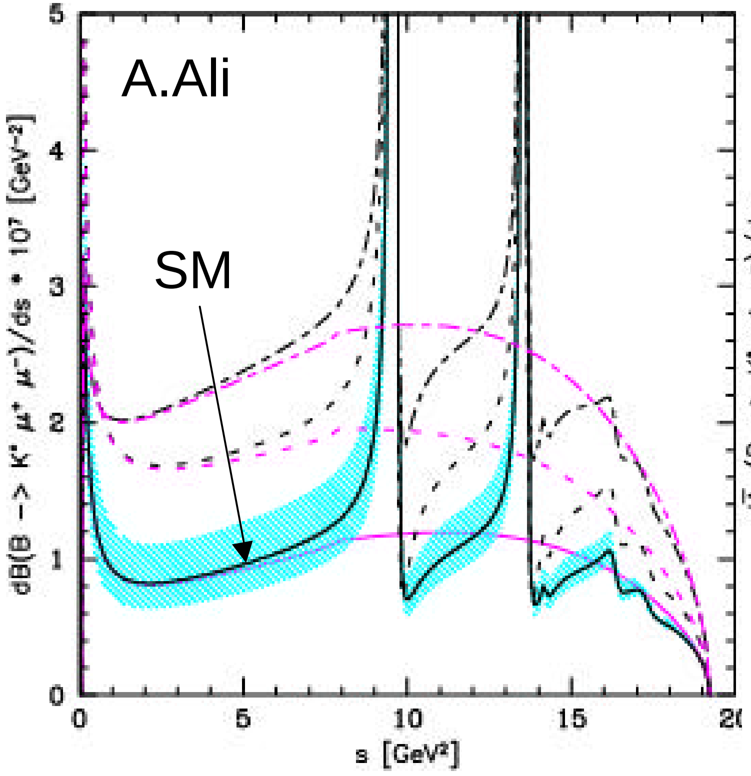
- Precise Br
- $M_{\mu\mu}$, $M_{\nu\nu}$ distributions
- F/B charge asymmetry



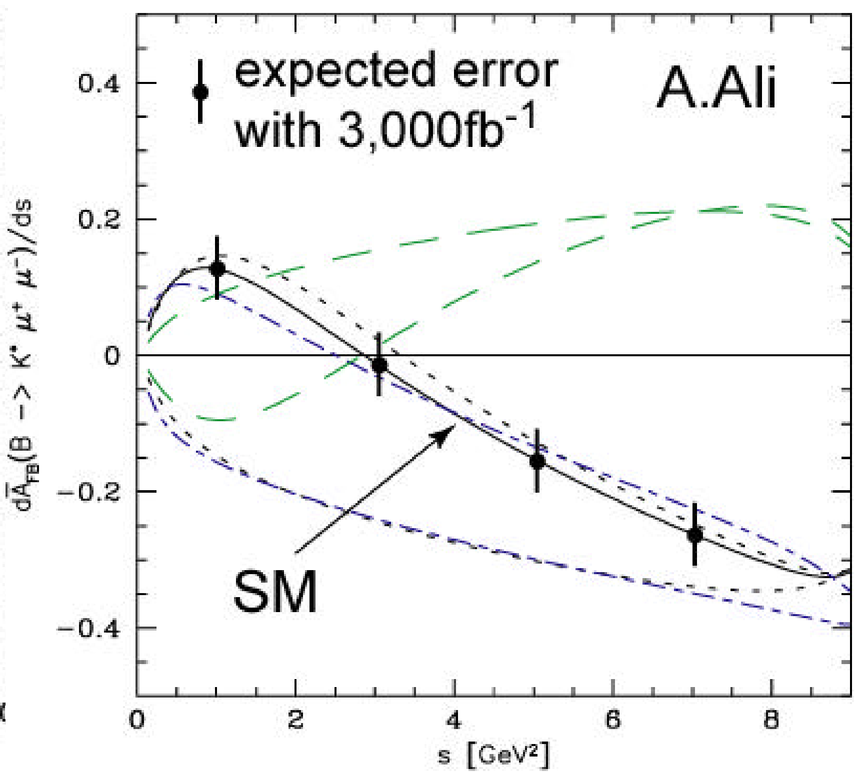
Need a few x 1000 fb^{-1}

$B \to K^*mm$

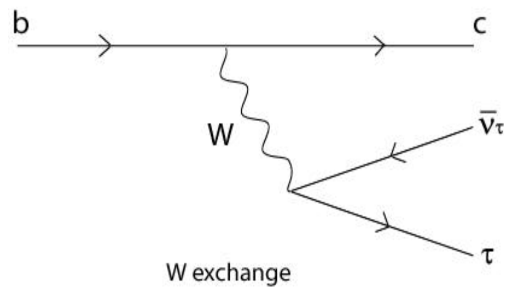
m(μμ)^2 distribution

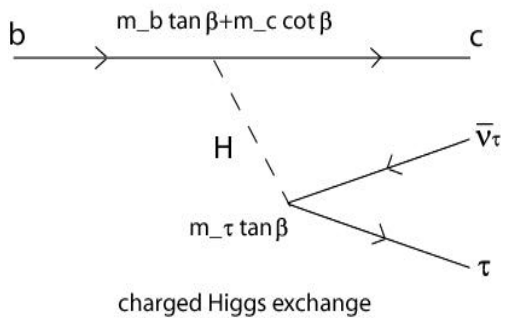


F/B asymmetry

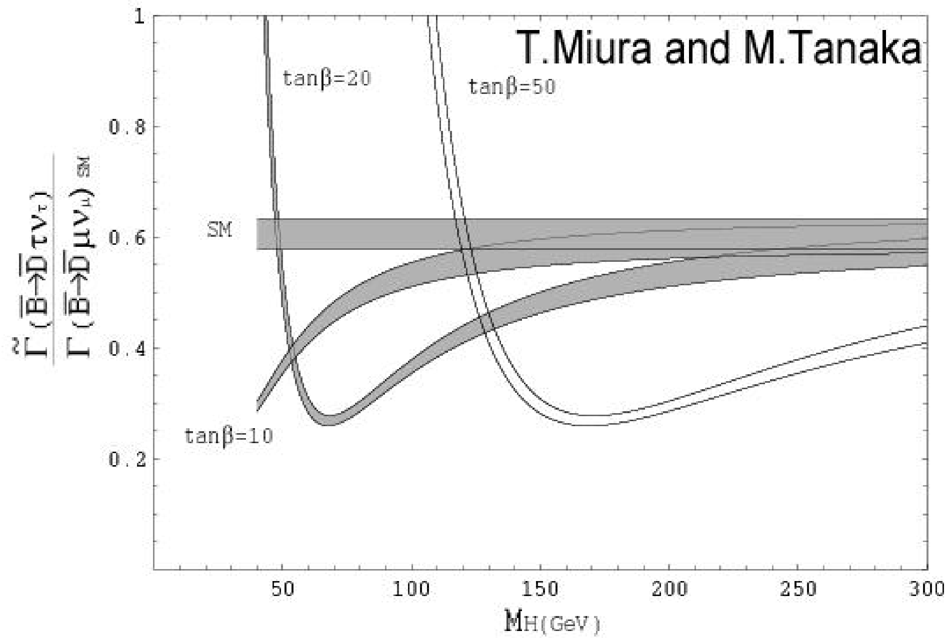


BSM in tree decay



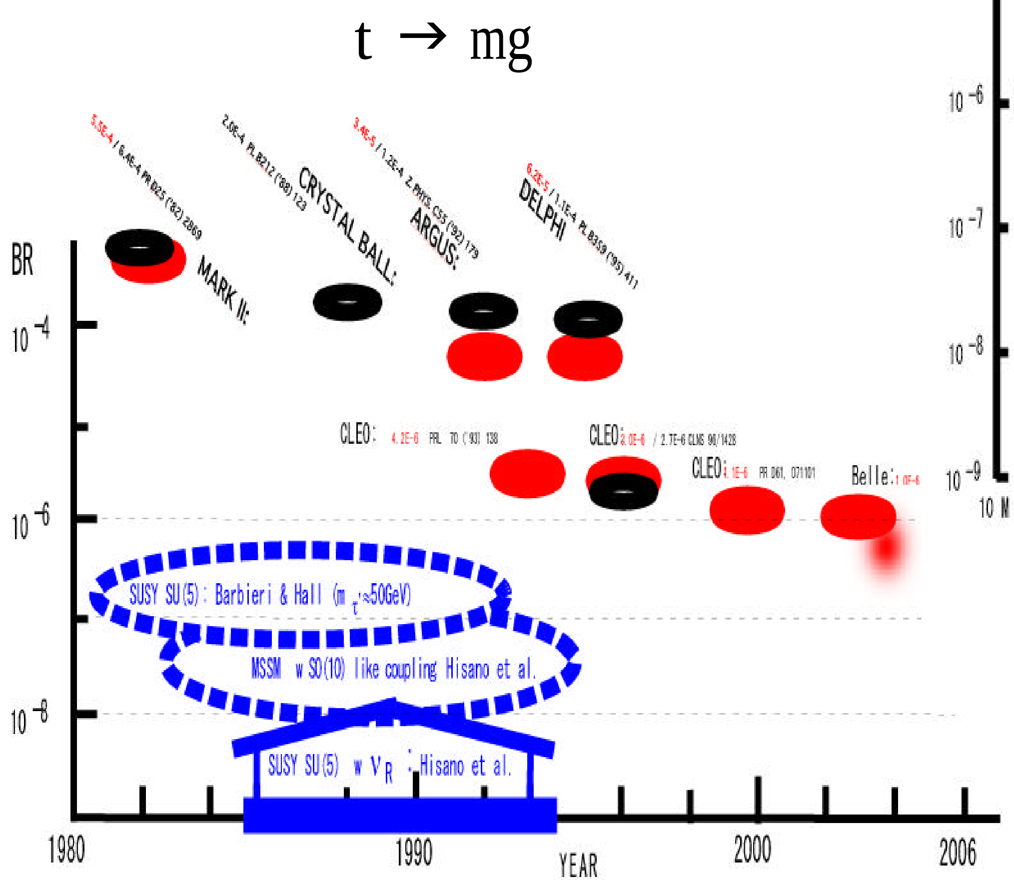


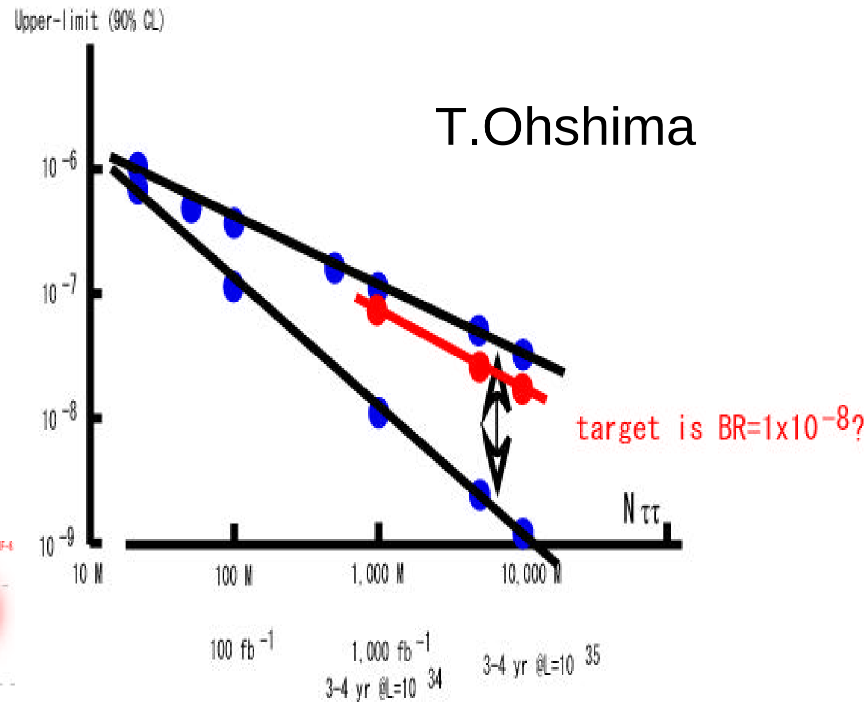
- Large Br of O(1)%
- Uncertainty in form factor cancels.
- τ polarization: exp. challenge



Need >1000fb^{-1}

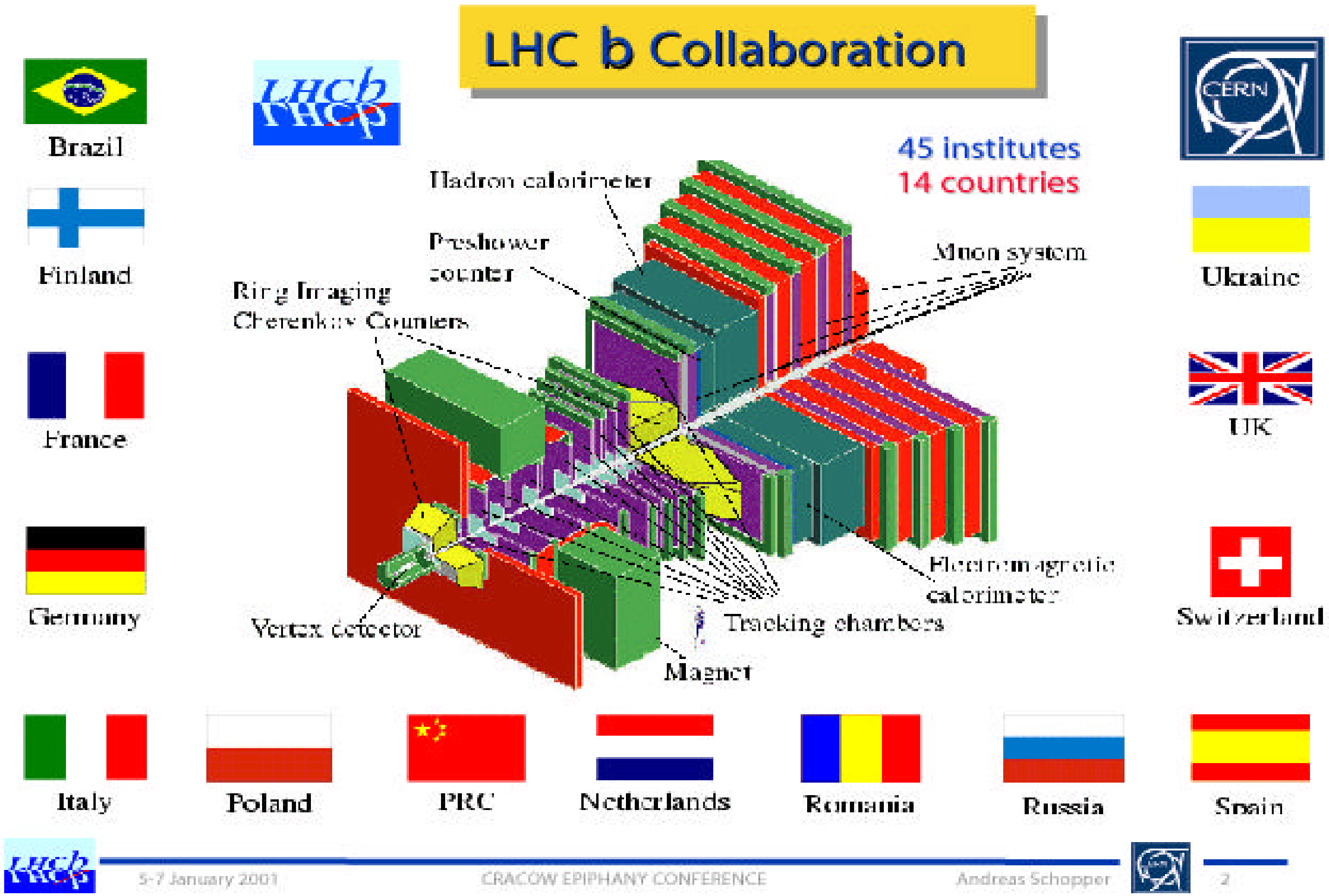
BSM in τ decay





Need > $1000 fb^{-1}$

Competition with hadron B factories



Hadron and e^+e^- B Factories

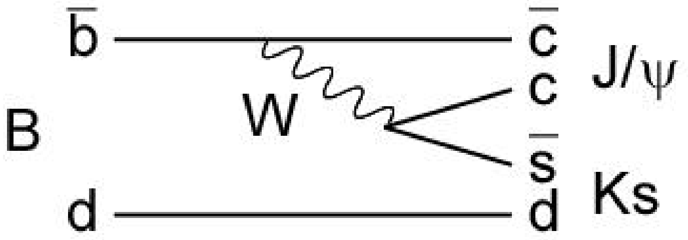
- Hadronic *B* factories have much higher *B* production rate.
- The e^+e^- machines are advantageous in the mesurements of:
  - *B* decays including γ / π^0 or (multiple) ν's or ϕ, and
  - inclusive BF's, e.g. $b \rightarrow s\gamma$ and $b \rightarrow sl^+l^-$.

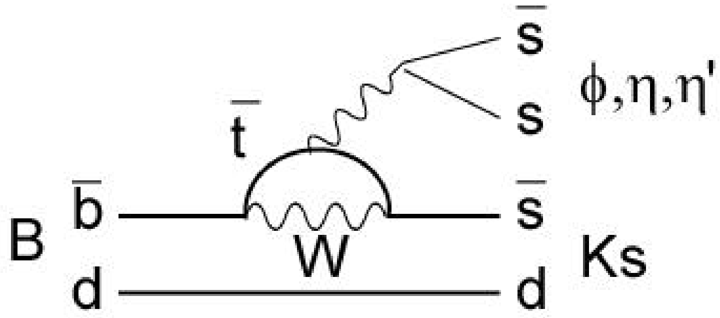
- A possible scenario of e^+e^- *B* factories:
  - Before the discovery of SUSY at LHC/ LC: Search for the hints in *B and t* decays and give constraints to the models.
  - After SUSY is discovered: Measure SUSY couplings including complex phases. ⟶ SUSY $\not{CP}$

Looking at SUSY ~~CP~~

Test the difference between the tree and penguin phases.

$$\phi_1(B \to J/\psi K_s) \stackrel{?}{=} \phi_1(B \to \phi K_s) \quad \text{: YES in KM}$$

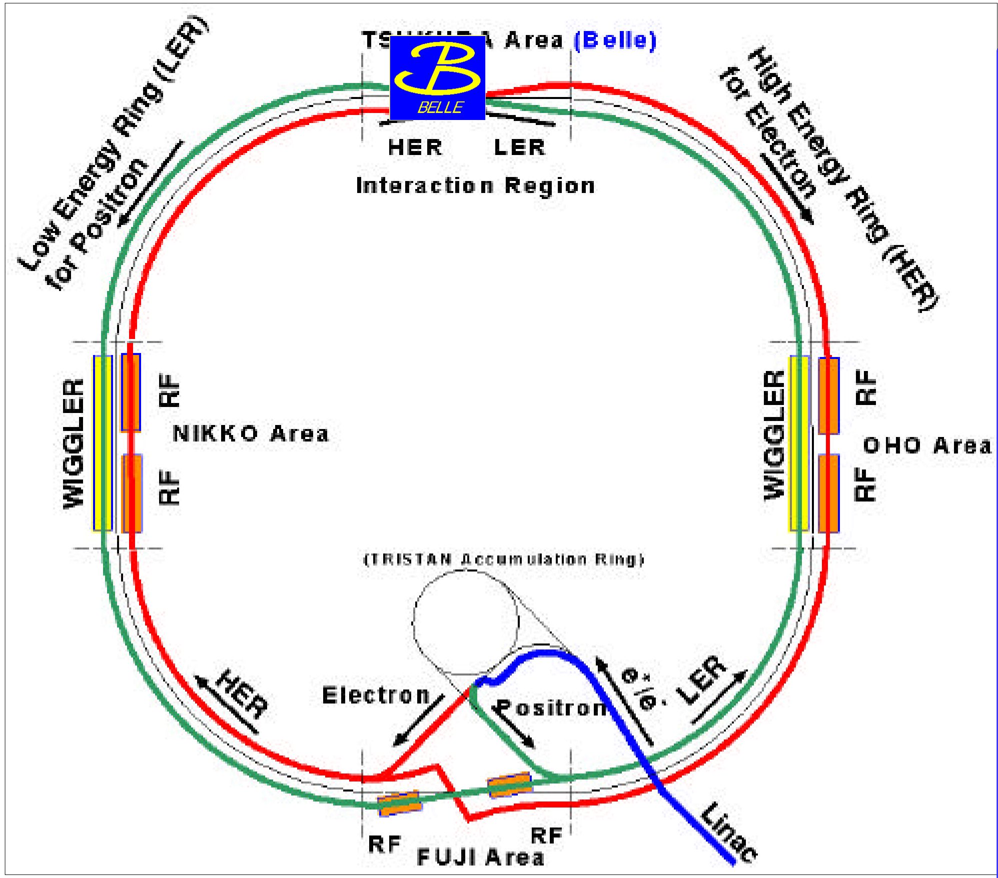




$\delta \sin 2\phi_1 \cong 0.02$ with 3000 fb^{-1}

$\delta \sin 2\phi_1 \cong 0.05$ with 3000 fb^{-1}

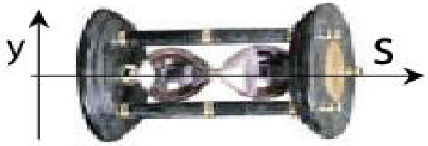
KEKB collider at present

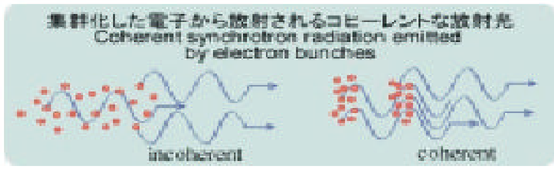


- **Two separate rings**
  - **e^+ (LER) : 3.5 GeV**
  - **e^- (HER) : 8.0 GeV**
- **E_{CM} : 10.58 GeV at U(4S)**
- **Luminosity**
  - **target: 10^{34} cm^{-2}s^{-1}**
  - **achieved: 5.4×10^{33}cm^{-2}s^{-1}**
- **±11 mrad crossing angle**
- **Small beam sizes:**
  - s_y **»3** m**m;** s_x **» 100** m**m**

Accelerator design – parameters

- To achieve 10^{35} $cm^{-2}s^{-1}$:
  - Squeeze β at I.P: $\beta_y{}^* = 3$ mm
  - Bunch length: $\sigma_z = 3$ mm
    - To reduce hourglass effect.
    - Is coherent radiation OK ?
  - Crossing angle: 2x 15 mrad
  - Higher beam current: 10 A for LER and 3 A for HER
    - Need higher emittance optics (?)
    - Particle exchange may become essential.





	KEKB 2001		KEKB (design)		Super KEKB	
Ring	LER	HER	LER	HER	LER	HER
Particle type	positron	electron	positron	electron	electron	positron
Beam energy (GeV)	3.5	8.0	3.5	8.0	3.5	8.0
Beam current (A)	0.96	0.78	2.6	1.1	10	3
Beam-beam (y)	0.05	0.03	0.05		0.03-0.05	
y (mm)	6.5		10		3	
Bunch length (mm)	5.5	5.7	4		3	
Emittance (nm)	18	24	18		18-54	
Number of bunches	1153		5120		5120	
Luminosity (/nb/s)	4.5		10		100	

Accelerator upgrade

7
Y.Onishi

Upgrade issues

- IR design
  - Configuration for special magnets(QCS, QC1, QC2).
  - IR aperture
- Optics
  - High emittance optics, IR optics, dynamic aperture.
- R F
  - HOM damper, couplers, etc. for higher beam current.
- Vacuum
  - Ante-chamber, photon stop, masks, etc.
- FB/Monitor
  - Bunch-by-bunch feedback, BPMs
- Injector
  - C-band acceleration
  - Recirculation with damping ring
- Cooling and electricity as institute

Injection linac – requirements

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

NEED Energy upgrade for e+ !

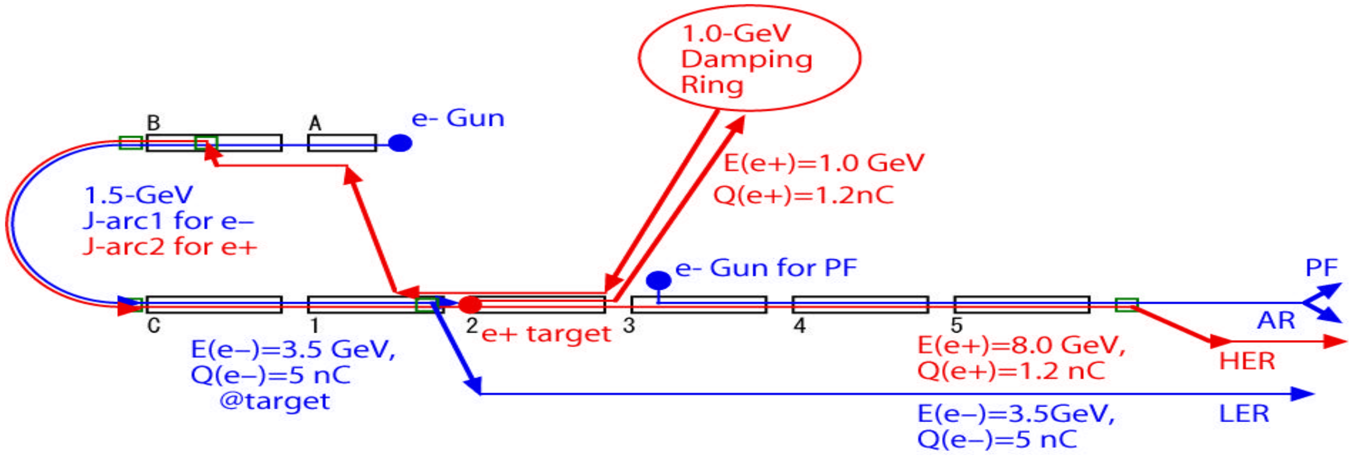
	July 2001		KEKB design		SuperKEKB
stored current (e−)	0.8 A	→	1.1 A	→	10.0 A !!
(e+)	0.9 A	→	2.6 A	→	3.0 A !!

NEED Intensity upgrade for e−/e+ !

Injection linac – possible solutions

- C-band option 21 ⟶ 40MV/m

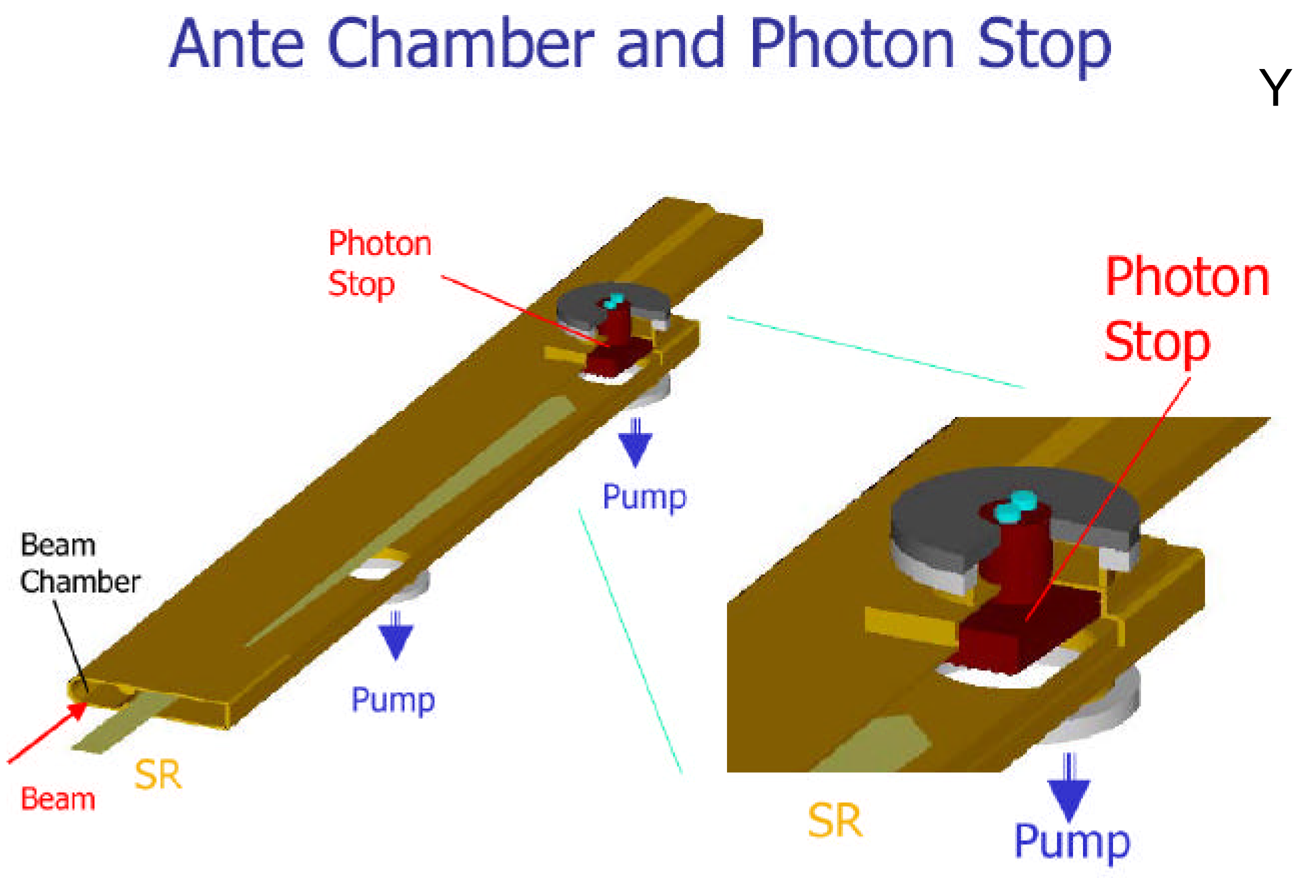
- Recirculation option



- e^- injection @15mA/s has no problem.

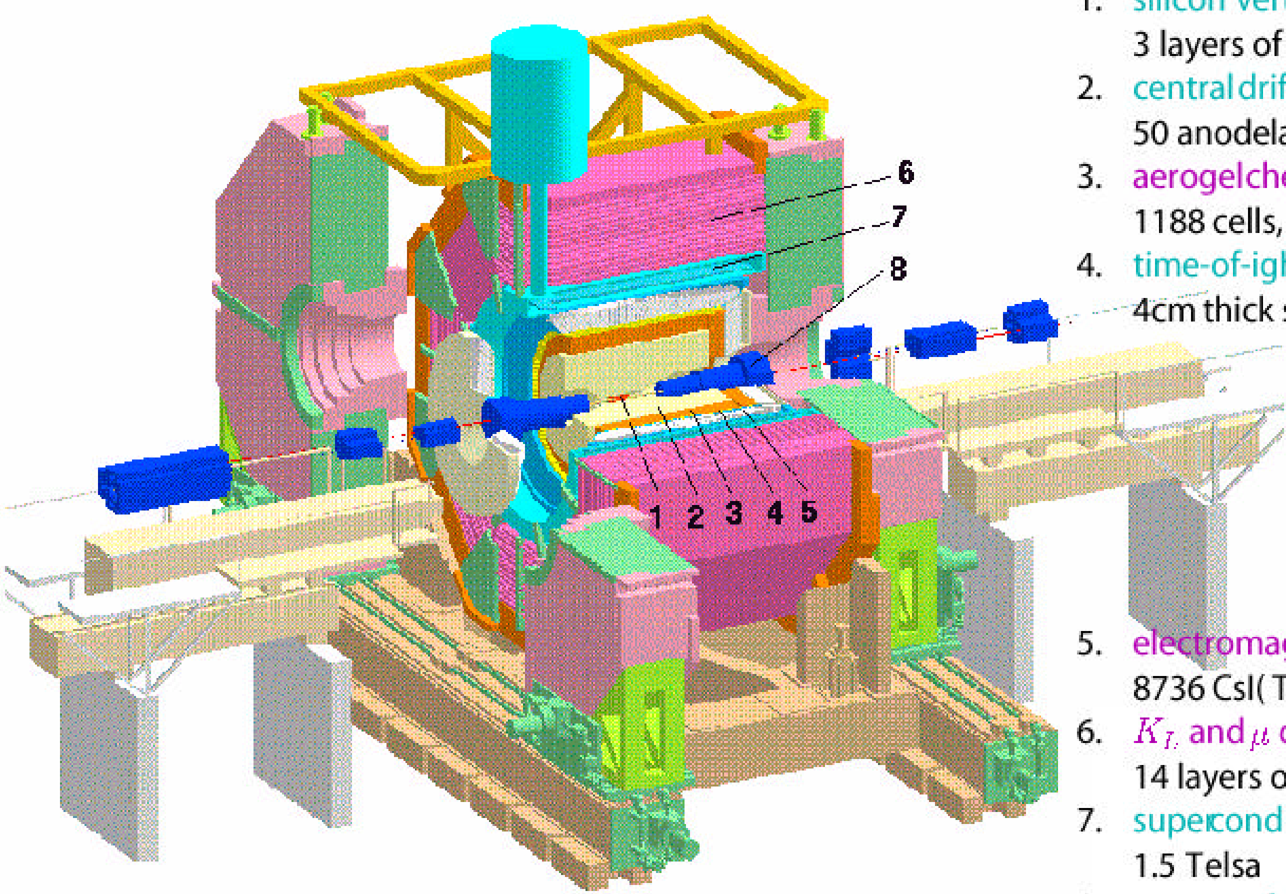
- e^+ injection @ 6mA/s: need two bunch accel. and larger e^+ acceptance

Vacuum system – photon stop



Y.Suetsugu

Detector – present Belle

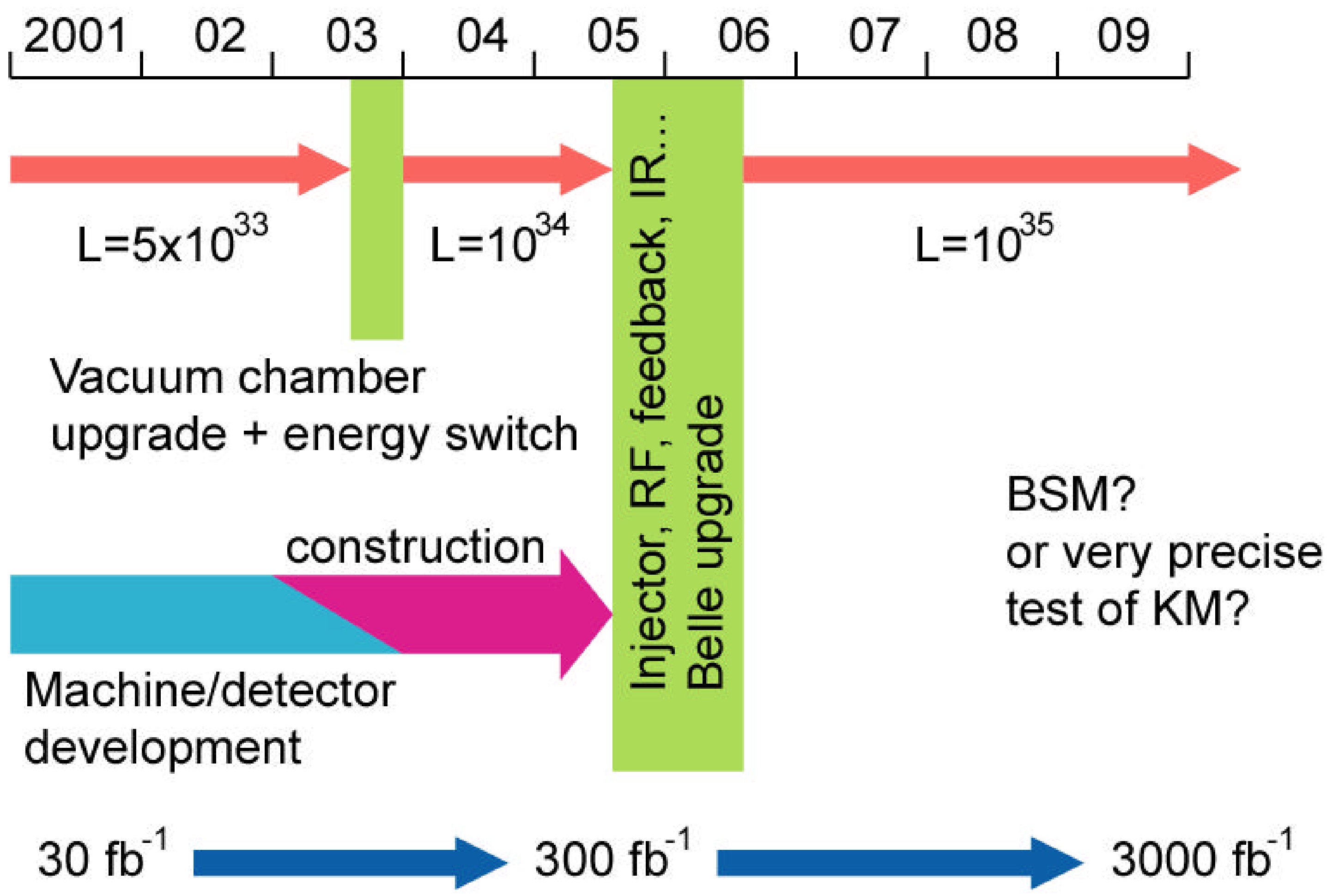


1. silicon vertex detector(SVD)
   3 layers of doublesided sensors
2. central drift chamber(CDC)
   50 anodelayers
3. aerogelcherenkov counters(A CC)
   1188 cells, $n = 1.01$ to 1.03
4. time-of-ight counters(T OF)
   4cm thick scintillator, 128 in ϕ
5. electromagneticcalorimeter(ECL)
   8736 CsI(Tl) crystals
6. K_L and μ detector(KLM)
   14 layers of glass RPC in iron yoke
7. superconductingsolenoid
   1.5 Telsa
8. extreme-forward calorimeter(EFC)
   320 BGO on top of nal focus quad

Detector upgrade

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

Schedule – an example



Summary

- KEKB/Belle has been running successfully, and discovered CP violation in *B* meson system.
- A possible extension of KEKB/Belle is considered to search for BSM in *B* and τ decays.

  - Precise test of the KM unitarity triangle.

  - Test of SUSY effects in the penguin loop.

  - Search for $H^{+/-}$ in *B* decays.

  - LFV τ decays.

  These are competitive with the hadron *B* factories.
- Machine/detector design is going on. The target date will be ~2006.