New Physics Search in B Decays (Leptonic and Neutrino Modes) & Super B Factory

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Heavy Quark and Leptons 2006 Munich

Talk Outline + Appology

- Introduction
- B→lν (τν, μν, eν, lνγ)
- B→ll (ee, μμ, ττ, llγ)
- B→K(*)νν, νν

- Super KEKB
- Summary

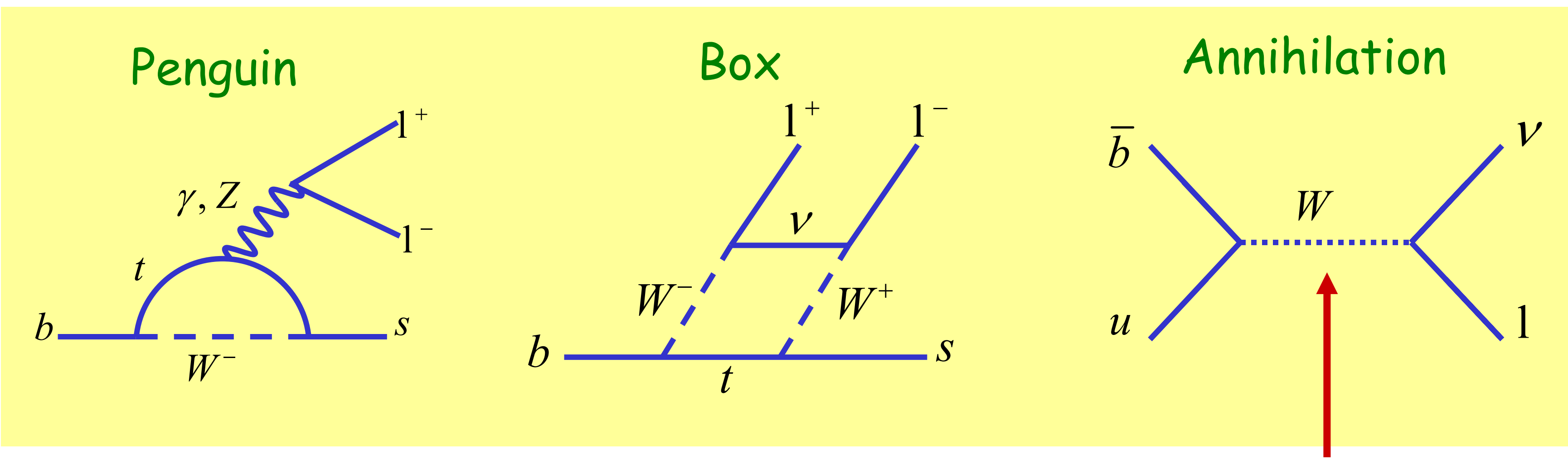
Appology:
Due to limited time, some of them cannot be mentioned or have to be put in backup .

Introduction

- If New Physics found at LHC at TeV scale, they must appear in loops as well and change amplitudes.

- It is easier to see the effects when SM amplitudes are small (or zero). ⇒ **Rare Decays !!**

- B decay has many patterns to test the effects.



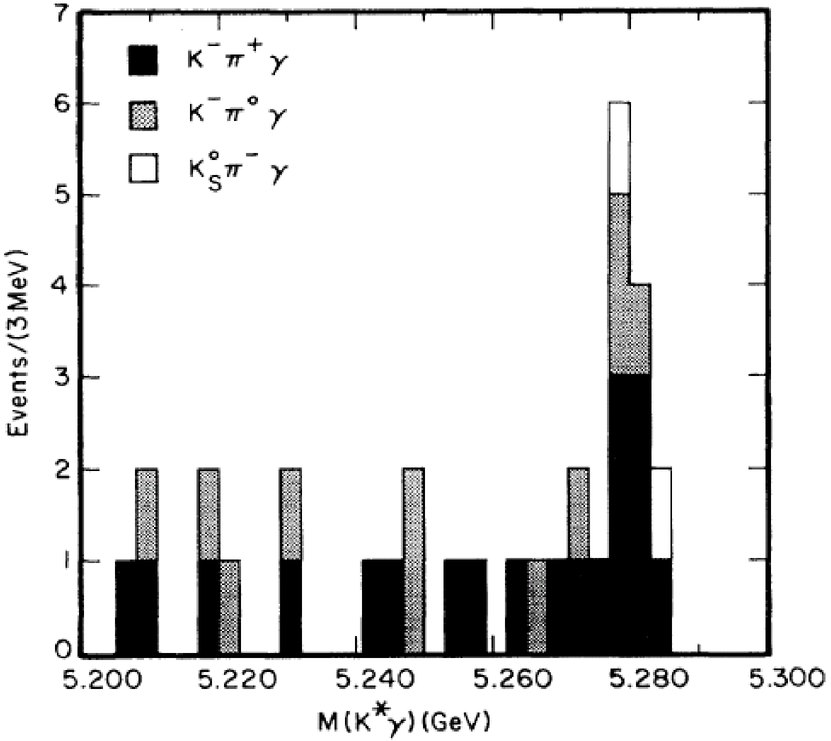
Higgs mediation

Hunting Rare Decays

In 1993…

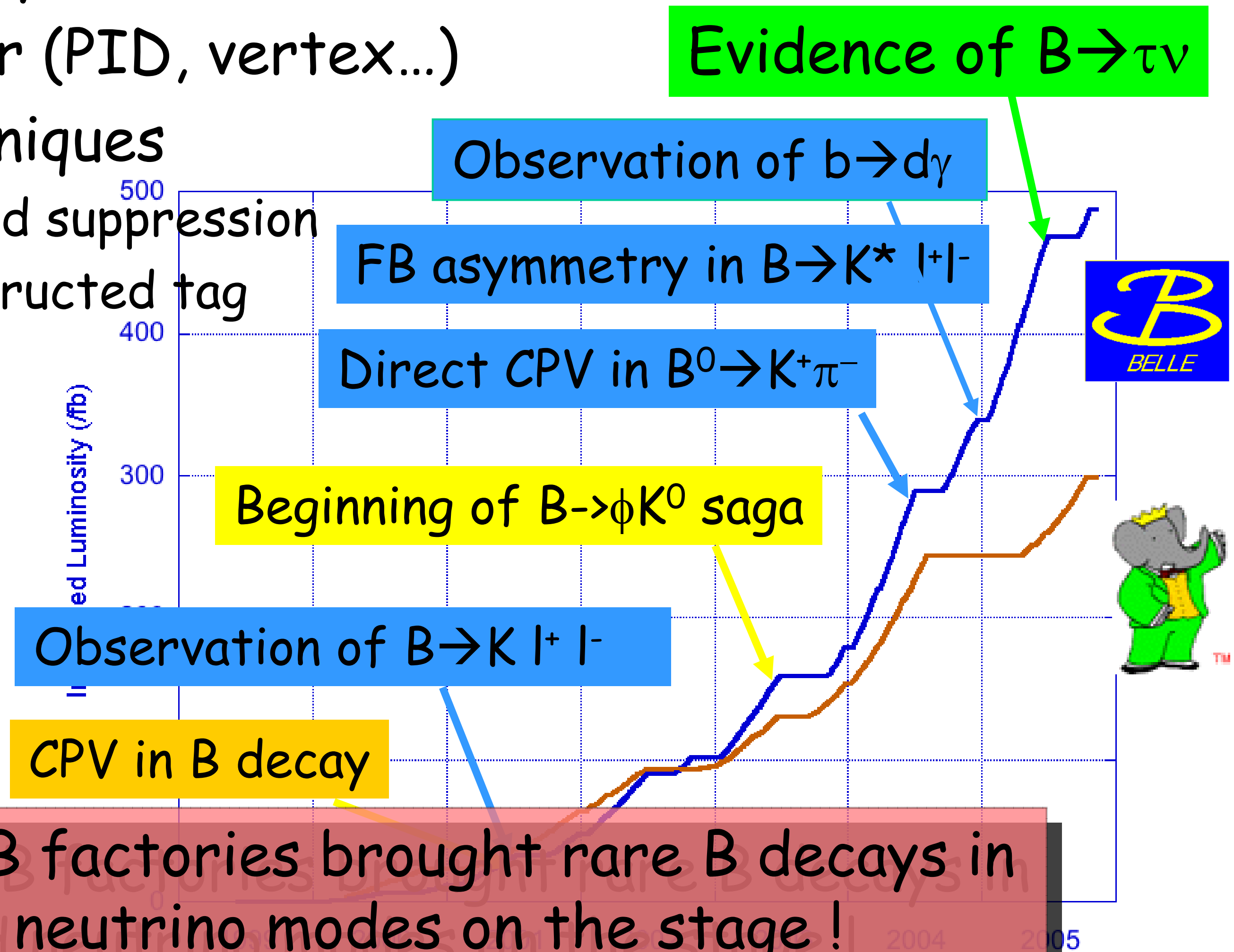
CLEO
First evidence of
$B \rightarrow K^*\gamma$

PRL 71, 674 (1993)



Hunting Rare Decays

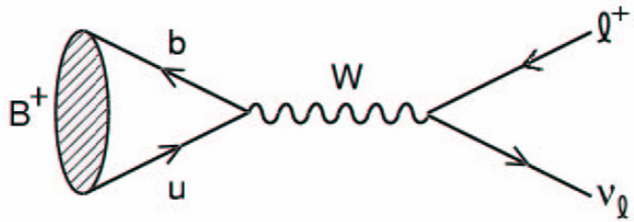
- High luminosity
- Good detector (PID, vertex…)
- Analysis techniques
  - qq background suppression
  - Fully reconstructed tag



Success of B factories brought rare B decays in leptonic and neutrino modes on the stage !

$B \to l\nu$

- Proceed via W annihilation in the SM.



- SM Branching fraction

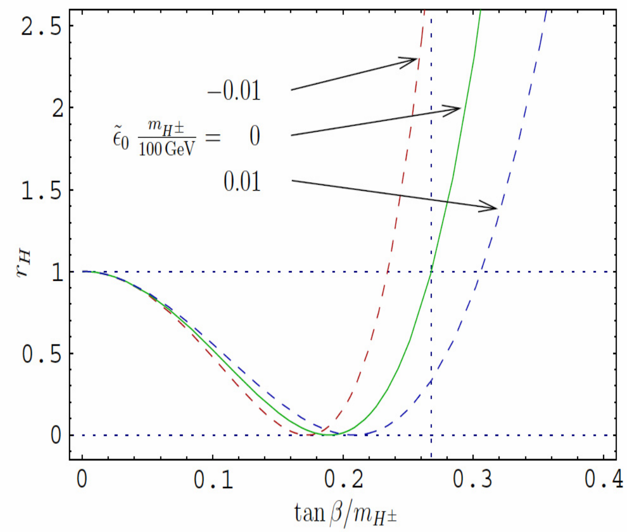
$$\mathcal{B}(B^- \to \ell^- \bar{\nu}) = \frac{G_F^2 m_B m_\ell^2}{8\pi}\left(1 - \frac{m_\ell^2}{m_B^2}\right)^2 f_B^2 |V_{ub}|^2 \tau_B$$

⇒ Provide $f_B|V_{ub}|$

$Br(\tau\nu)=1.6\times10^{-4}$
$Br(\mu\nu)=7.1\times10^{-7}$
$Br(e\nu)=1.7\times10^{-11}$

- In two Higgs doublets model, charged Higgs exchange interferes with the helicity suppressed W-exchange.

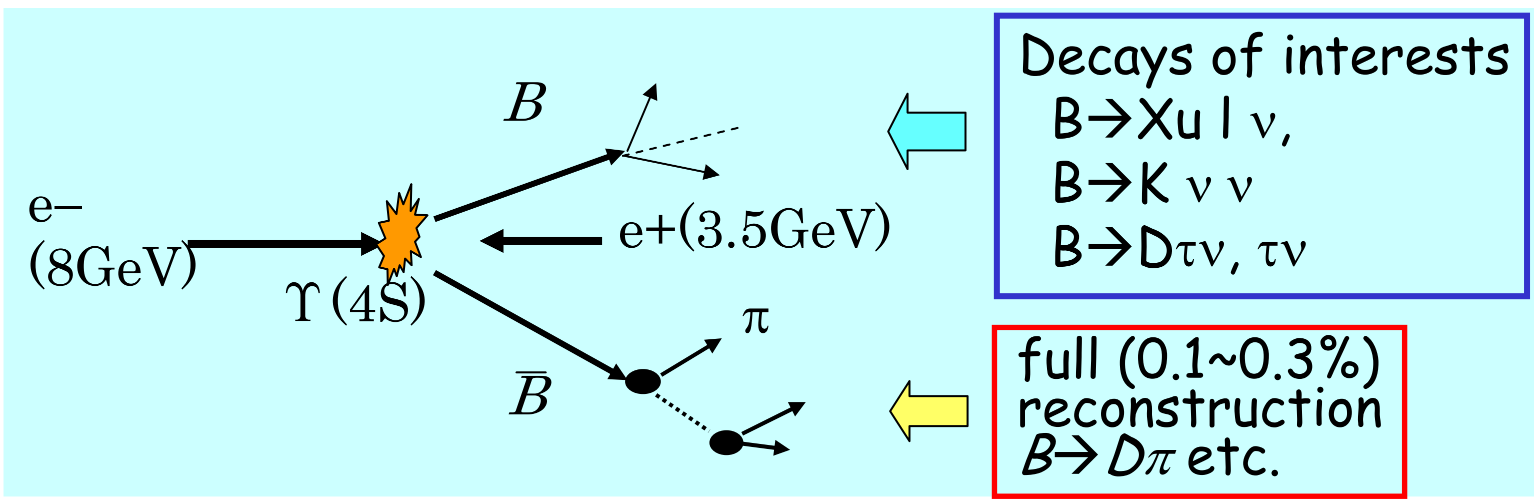
$$Br = Br_{SM} \times r_H,\quad r_H = \left(1 - \frac{m_B^2}{m_H^2}\tan^2\beta\right)^2$$



- If $\mu\nu$ is also measured, lepton universality can be tested.
  → SUSY correction etc.

Full Reconstruction Method

- Fully reconstruct one of the B's to tag
  - B production
  - B flavor/charge
  - B momentum



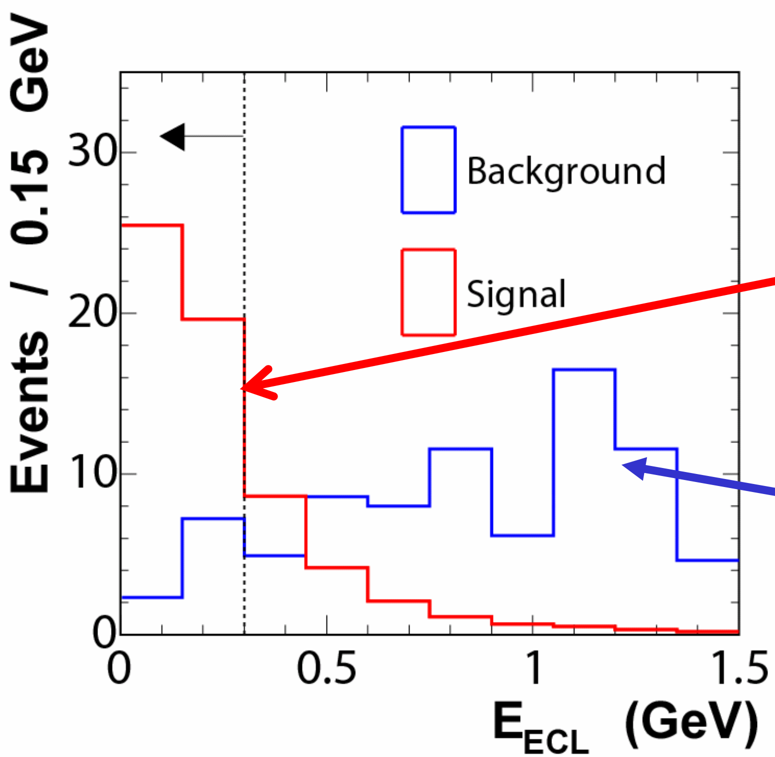
Single B meson beam in offline !

Powerful tools for B decays w/ neutrinos

B→τν Analysis

- Extra neutral energy in calorimeter E_{ECL}
  - Most powerful variable for separating signal and background
  - Total calorimeter energy from the neutral clusters which are not associated with the tag B

$$E_{ECL} = E_{tot} - E_{rec.\ B} \quad (-E_{\pi^0} \text{ for } \pi^-\pi^0\nu)$$



Minimum energy threshold

- **Barrel : 50 MeV**
- **For(Back)ward endcap : 100(150) MeV**

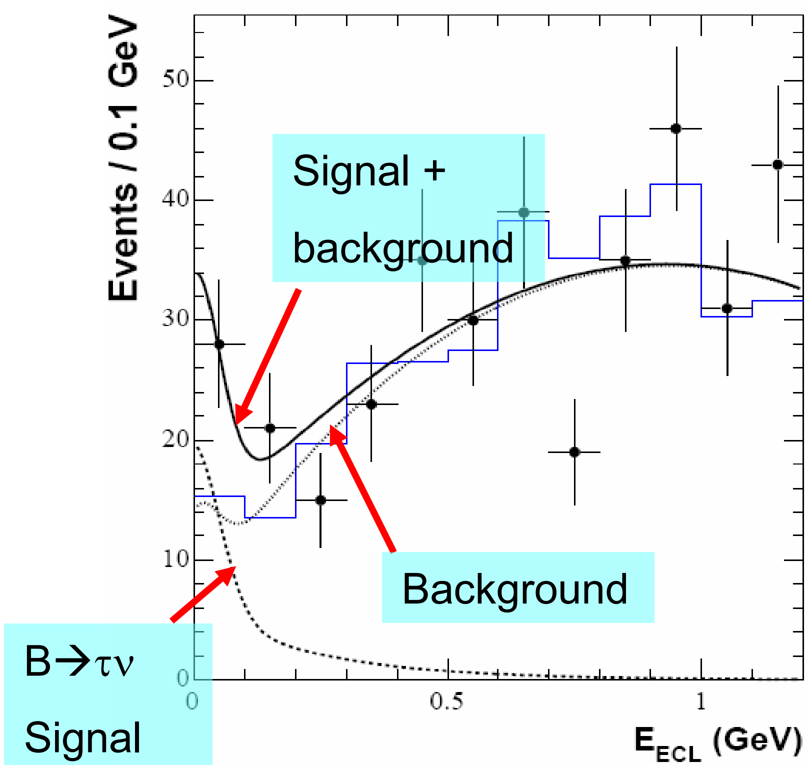
Zero or small value of E_{ECL} arising only from beam background

Higher E_{ECL} due to additional neutral clusters

MC includes overlay of random trigger data to reproduce beam backgrounds.

The First $B \to \tau\nu$ Evidence

- The final results are deduced by unbinned likelihood fit to the obtained E_{ECL} distributions.



	N_{obs}	N_s	N_b	Σ
$\mu^- \bar{\nu}_\mu \nu_\tau$	13	$5.6^{+3.1}_{-2.8}$	$8.8^{+0.1}_{-0.1}$	2.7σ
$e^- \bar{\nu}_e \nu_\tau$	12	$4.1^{+3.3}_{-2.6}$	$9.0^{+0.1}_{-0.1}$	1.8σ
$\pi^- \nu_\tau$	9	$3.8^{+2.7}_{-2.1}$	$3.9^{+0.1}_{-0.1}$	2.4σ
$\pi^- \pi^0 \nu_\tau$	11	$5.4^{+3.9}_{-3.3}$	$5.4^{+0.6}_{-0.6}$	1.7σ
$\pi^- \pi^+ \pi^- \nu_\tau$	9	$3.0^{+3.5}_{-2.5}$	$4.8^{+0.4}_{-0.4}$	1.1σ
Combined	54	$17.2^{+5.3}_{-4.7}$	$32.0^{+0.7}_{-0.7}$	4.6σ

Σ : Statistical Significance

Observe $17.2^{+5.3}_{-4.7}$ events in the signal region.

Significance decreased to 3.5 σ after including systematics

Signal shape : Gauss + exponential

Background shape : second-order polynomial + Gauss (peaking component)

Results (Br & f_B Extraction)

- Measured branching fraction;

$$Br(B \to \tau\nu) = \left(1.79\,^{+0.56}_{-0.49}\,^{+0.46}_{-0.51}\right) \times 10^{-4}$$

- Product of B meson decay constant f_B and CKM matrix element $|V_{ub}|$

$$f_B |V_{ub}| = \left(10.1\,^{+1.6}_{-1.4}\,^{+1.3}_{-1.4}\right) \times 10^{-4}\,GeV$$

- Using $|V_{ub}| = (4.39 \pm 0.33) \times 10^{-3}$ from HFAG

$$f_B = 0.229\,^{+0.036}_{-0.031}\,^{+0.034}_{-0.037}\,GeV$$

15% 16% = 14%(exp.) + 8%(V_{ub})

$\Leftrightarrow$ $f_B = 216 \pm 22$ MeV

[HPQCD, Phys. Rev. Lett. 95, 212001 (2005)]

Correction to the FPCP06 result

- Error in the efficiency calculation.
  - Due to a coding error, the efficiency quoted in the 1st Belle preliminary result was incorrect.

- Treatment of the peaking background component.
  - Peaking component is subtracted for the central value.
  - Re-evaluate its systematic uncertainty.

- The data plots and event sample are unchanged. However, f_B and the branching fraction must be changed.

New value $$\mathrm{BF}(B^+ \to \tau^+ \nu_\tau) = (1.79^{+0.56+\cancel{0.39}\;0.46}_{-0.49-\cancel{0.46}\;0.51}) \times 10^{-4}$$

FPCP04 result $$\cancel{\mathrm{BF}(B^+ \to \tau^+ \nu_\tau) = 1.06^{+0.34+0.18}_{-0.28-0.16} \times 10^{-4}}$$

The revised paper is being (has been) resubmitted, and posted as hep-ex/0604018v2.

$B \to \tau\nu$ Search @ Babar

- Babar searches for in a sample of 324×10^6 BB events
  - Reconstruct one B in a semileptonic final state $B \to Dl\nu X$

    $D \to K\pi$, $K\pi\pi\pi$, $K\pi\pi$, $K_s\pi\pi$ ($X=\gamma$, π from D*0 is not explicitly reconstructed)

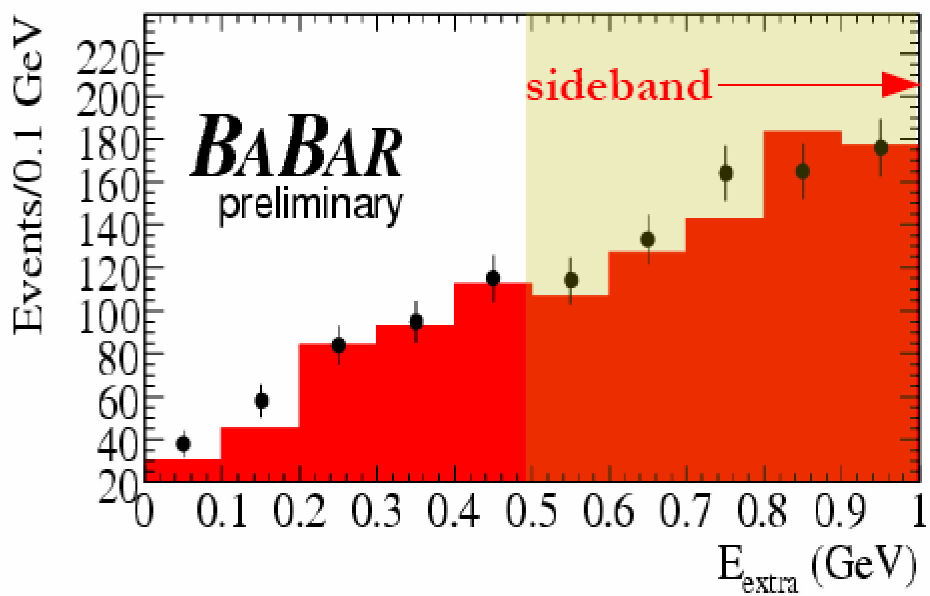
    - Require lepton CM momentum > 0.8 GeV
    - Require that $-2 < \cos\theta_{B\text{-}D0l} < 1$
    - Parent B energy and momentum are determined from the beam energy

    $$\cos\theta_{B-D\ell} = \frac{2E_B E_{D\ell} - m_B^2 - m_{D\ell}^2}{2|p_B p_{D\ell}|}$$

  - Tagged B reconstruction efficiency ~0.7%

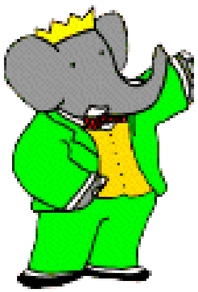
- Discriminate signal from background using E_{extra}
  - τ lepton is identified in the 4 decay modes

$$\tau^- \to \mu^-\nu\bar{\nu},\ e^-\nu\bar{\nu},$$
$$\pi^-\nu,\ \pi^-\pi^0\nu$$



$B \to \tau\nu$ Search @ Babar (cont.)

- Observed excess is not significant yet (1.3σ), and set a limit on the branching fraction and quote a central value.



Selection	Background	Observed Events
$\mu^-\bar{\nu}_\mu\nu_\tau$	41.9 ± 5.2	51
$e^-\bar{\nu}_e\nu_\tau$	35.4 ± 4.2	36
$\pi^-\nu_\tau$	99.1 ± 9.1	109
$\pi^-\pi^0\nu_\tau$	15.3 ± 3.5	17
All modes	191.7 ± 11.8	213

$$\mathcal{B}(B \to \tau\nu) < 1.8 \times 10^{-4} (90\%\text{C.L.})$$

Babar preliminary

$$\mathcal{B}(B \to \tau\nu) = (0.88^{+0.68}_{-0.67}(\text{stat}) \pm 0.11(\text{syst})) \times 10^{-4}$$

Deduced $f_B\,|V_{ub}|$

$$f_B \cdot |V_{ub}| = (7.0^{+2.3}_{-3.6}(\text{stat})^{+0.4}_{-0.5}(\text{syst})) \times 10^{-4}\ \text{GeV}$$

Constraints on Charged Higgs

$$Br_{exp} = (1.79\,^{+0.56}_{-0.49}\,^{+0.46}_{-0.51}) \times 10^{-4}$$

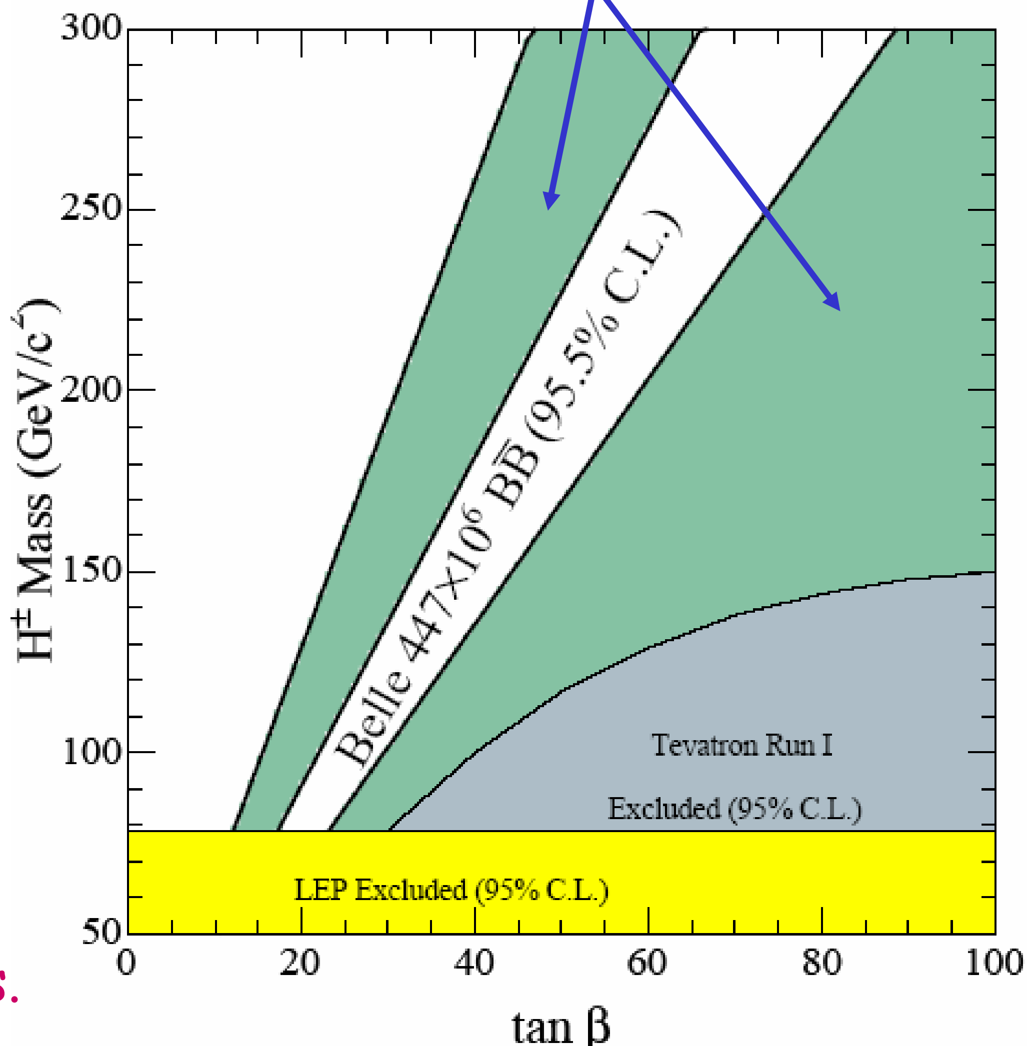
$$Br_{SM} = (1.59 \pm 0.40) \times 10^{-4}$$

f_B from HPQCD
$|V_{ub}|$ from HFAG

$$r_H = \left(1 - \frac{m_B^2}{m_H^2}\tan^2\beta\right)^2 = \frac{Br_{exp}}{Br_{SM}} = 1.13 \pm 0.53$$

Much stronger constraint than those from energy frontier exp's.

These regions are excluded.



Future Prospect: $B \rightarrow \tau\nu$

- $Br(B \rightarrow \tau\nu)$ measurement:

  More luminosity help to reduce both stat. and syst. errors.
  - Some of the syst. errors limited by statistics of the control sample.

- $|V_{ub}|$ measurement: < 5% in future is an realistic goal.

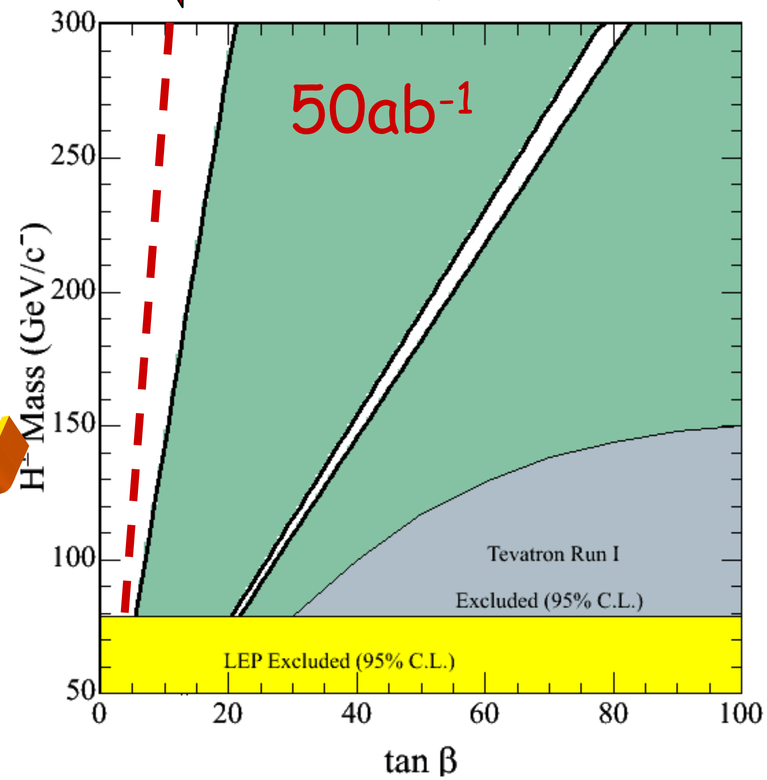
- f_B from theory: ~10% now → 5% ?

My assumption $\Delta f_B(LQCD) = 5\%$

Lum.	$\Delta B(B \rightarrow \tau\nu)_{exp}$	$\Delta \lvert V_{ub} \rvert$
414 fb^{-1}	36%	7.5%
5 ab^{-1}	10%	5.8%
50 ab^{-1}	3%	4.4%

Preliminary

If $\Delta|V_{ub}| = 0$ & $\Delta f_B = 0$



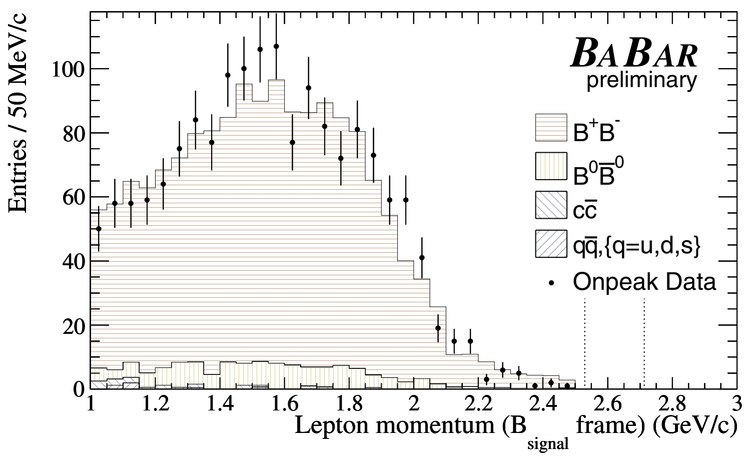
$Br(B \rightarrow \tau\nu)/\Delta m_d$ to cancel f_B ?

G.Isidori&P.Paradisi, hep-ph/0605012

B→μν, eν

- BaBar @ 208.7fb^{-1}

w/ fully reconstructed tag; B→$D^{(*)}$ X.



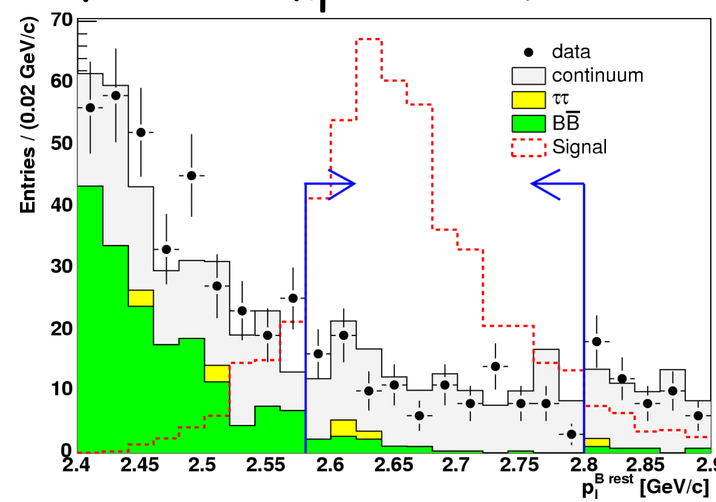
Nobs = 0 in the signal box.

$$Br(B\to e\nu) < 7.9\times10^{-6}$$
$$Br(B\to \mu\nu) < 6.2\times10^{-6}$$

@90%C.L.

- Belle @ 140fb^{-1}

w/ “inclusive ” reconstruction of the companion B.



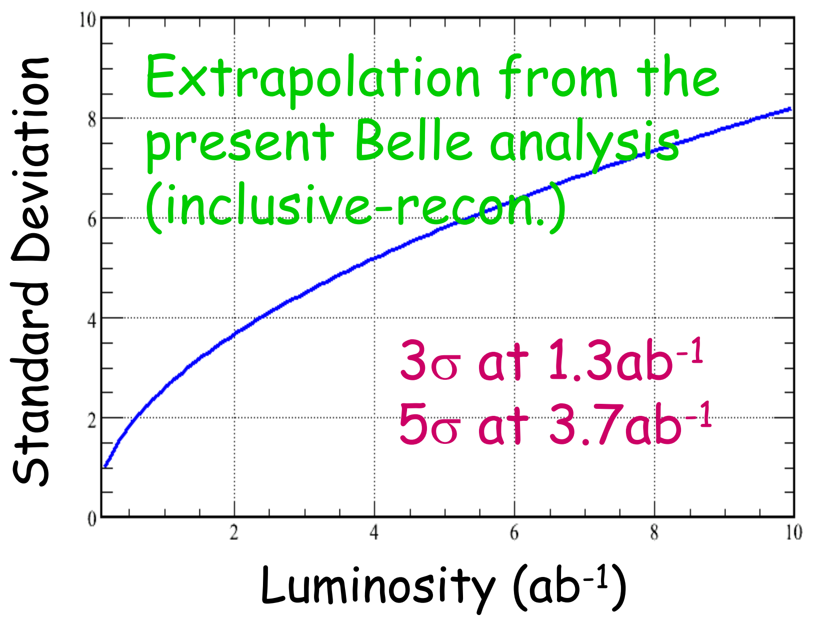
$$Br(B\to e\nu) < 5.4\times10^{-6}(60fb^{-1})$$
$$Br(B\to \mu\nu) < 2.6\times10^{-6}(140fb^{-1})$$

@90%C.L.

Future Prospect: $B \to \mu\nu$

- $B \to \mu\nu$ is the next milestone decay mode.
- Measurements will offer a cross check to the results obtained by $B \to \tau\nu$.
  - $f_B|V_{ub}|$ determination.
  - Test the lepton universality.

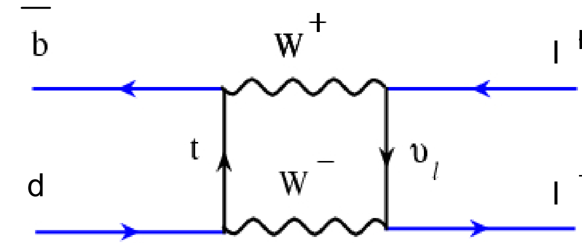
K.Ikado at BNM2006

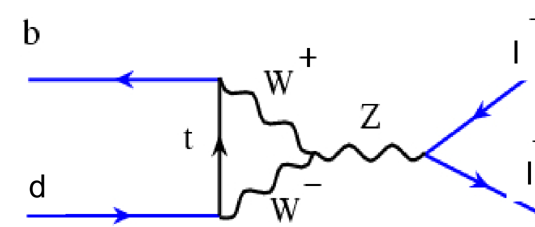


- Method?
  - Inclusive-recon method has high efficiency but poor S/N. $\text{limit} \propto 1/\sqrt{L}$
  - Hadronic tag will provide very clean and ambiguous signals, but very low efficiency. $\text{limit} \propto 1/L$

See also talk by Robertson at CERN flavour WS (May 2006)

$B^0 \rightarrow l^+ l^-$



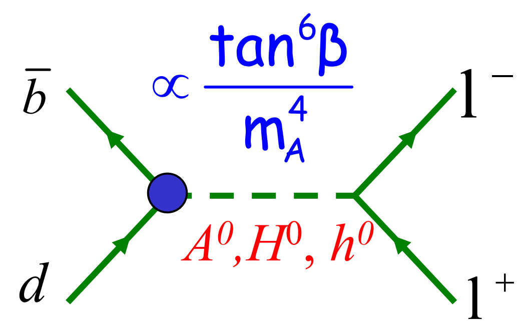


- Proceeds via box or penguin annihilation
  SM Branching fractions

$$Br(B_d^0 \rightarrow e^+ e^-) \sim 10^{-15}$$
$$Br(B_d^0 \rightarrow \mu^+ \mu^-) \sim 10^{-10}$$
$$Br(B_d^0 \rightarrow \nu \bar{\nu}) = \text{zero}$$

Flavor violating channel ($B^0 \rightarrow e^+ \mu^-$, etc.) are forbidden in SM.

- New Physics can enhance the branching fractions by orders of magnitude.
  ex.) loop-induced FCNC Higgs coupling



Note:

$$\frac{Br(B_s \rightarrow ll)}{Br(B_d \rightarrow ll)} = \left(\frac{V_{ts}}{V_{td}}\right)^2 ;\ 25$$

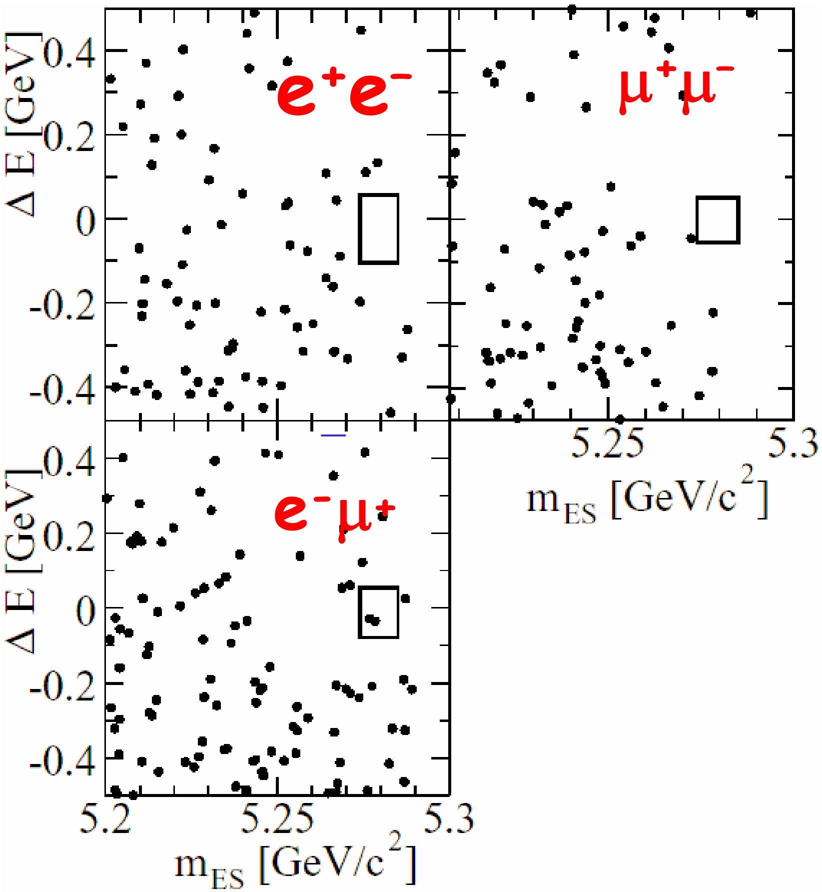
→ Present CDF limit; Br(Bs→μμ) < 1×10^{-7} (95%CL) is equivalent to Br(Bs→μμ) < 4×10^{-9}.

$$\frac{Br(B \rightarrow \tau\tau)}{Br(B \rightarrow \mu\mu)} = \left(\frac{m_\tau}{m_\mu}\right)^2 ;\ 300$$

→ B→ττ requires full-reco. tag.

$B^0 \to l^+l^-$ (e^+e^-, $\mu^+\mu^-$, $e^+\mu^-$)

Signal regions



Events observed

channel	$N_{\rm obs}$	$N^{\rm bg}_{\rm exp}$	$\varepsilon[\%]$	$\mathcal{B}_{\rm UL}(B^0 \to \ell^+\ell^-)$
$B^0 \to e^+e^-$	0	0.71 ± 0.31	21.8 ± 1.2	6.1×10^{-8}
$B^0 \to \mu^+\mu^-$	0	0.72 ± 0.26	15.9 ± 1.1	8.3×10^{-8}
$B^0 \to e^\pm\mu^\mp$	2	1.29 ± 0.44	18.1 ± 1.2	18×10^{-8}

111 fb^{-1}

$B(B^0 \to e^+e^-) < 6.1 \times 10^{-8}$ (90%CL)
$B(B^0 \to \mu^+\mu^-) < 8.3 \times 10^{-8}$ (90%CL)
$B(B^0 \to e^+\mu^-) < 18 \times 10^{-8}$ (90%CL)

Phys. Rev. Lett. 94, 221803 (2005)

BELLE

78 fb^{-1}

$B(B^0 \to e^+e^-) < 1.9 \times 10^{-7}$ (90%CL)
$B(B^0 \to \mu^+\mu^-) < 1.6 \times 10^{-7}$ (90%CL)
$B(B^0 \to e^+\mu^-) < 1.7 \times 10^{-7}$ (90%CL)

Phys. Rev. D 68, 111101 (2003)

CDF

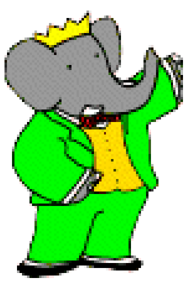
780 pb^{-1}

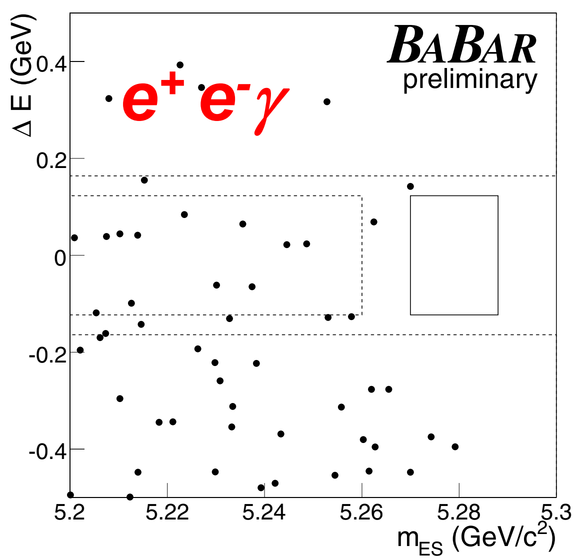
$B(B^0_d \to \mu^+\mu^-) < 2.3 \times 10^{-8}$ (90% CL)

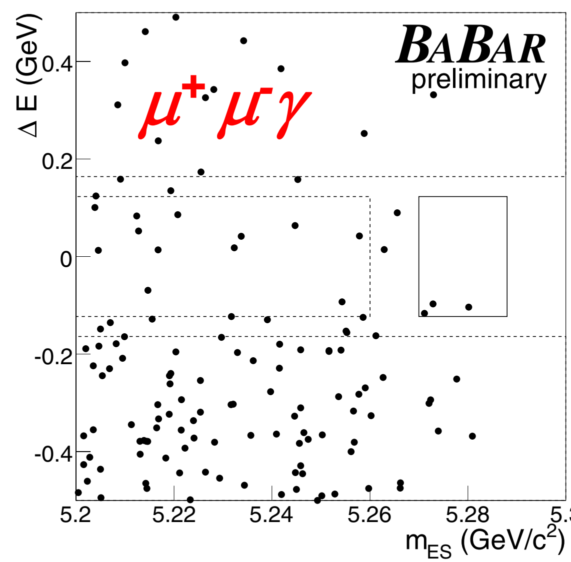
It would be interesting to see results with more data.
What about $\Upsilon(5S)$ data at Super-B ?

$B^0 \rightarrow ll\gamma$ (BaBar@ 292fb^{-1})

- 320 M BB events
- $0.3 < m_{ll} < 4.9$ (4.7) GeV for $ee\gamma$ ($\mu\mu\gamma$)
- Background from J/ψ, ψ (2S) decay (leptons) or π^0 decay (γ)
- Reject qq background event shape in a Fisher discriminant
- Observe 0 (3) events in the signal box in electron (muon) events





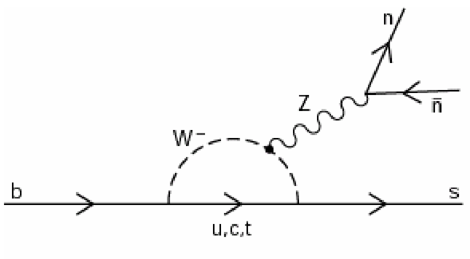


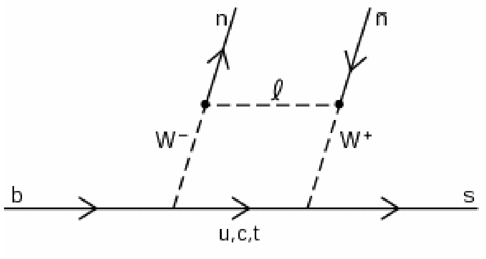
$B(B^0 \rightarrow e^+e^-\gamma) < 0.7 \times 10^{-7}$ (90%CL)
$B(B^0 \rightarrow \mu^+\mu^-\gamma) < 3.4 \times 10^{-7}$ (90%CL)

Babar preliminary

B→K(*) ν ν (b→s w/ two ν's)

- B→K(*)νν proceeds via one-loop radiative penguin and box diagrams.



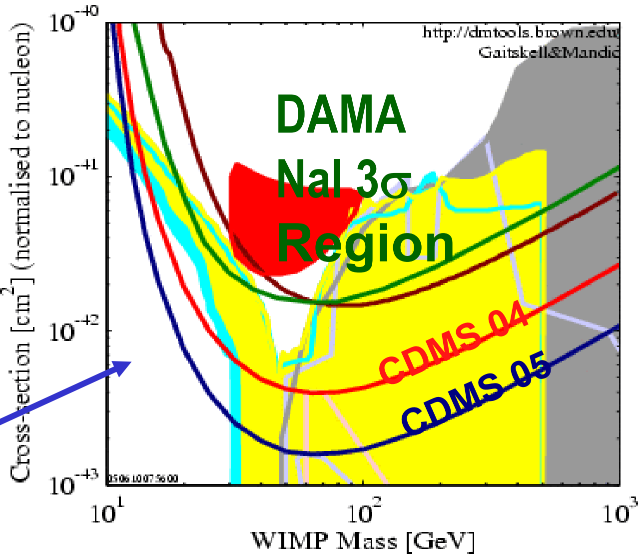


SM prediction
Br ~ 4×10^{-6}.

- It is highly sensitive to new physics, and theoretically very clean.
- But, experimentally very challenging.
  Signature: B→K(*) + nothing.

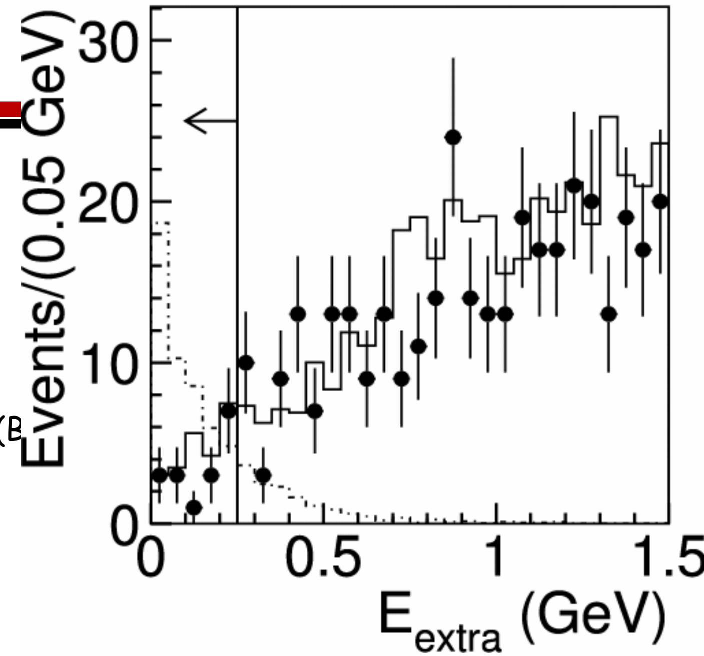
- Nothing may be light dark matter
  (see papers by Pespelov et al.).

Direct dark matter search cannot see M<10GeV region.

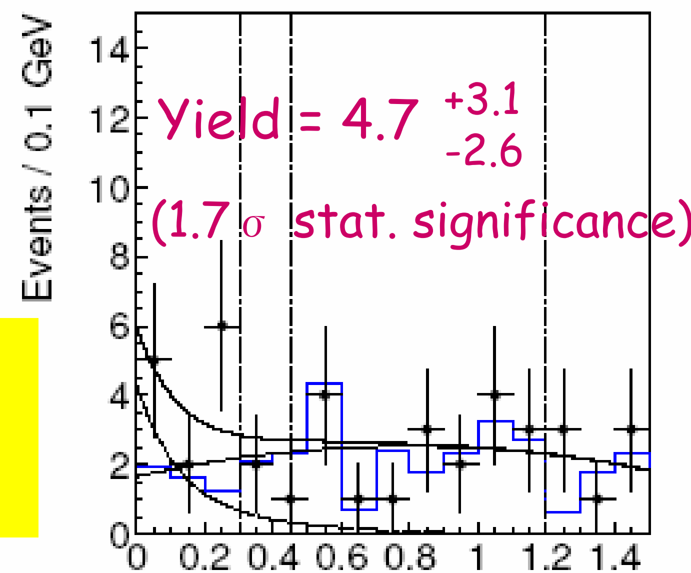


B→K$^{(*)}\nu\nu$

- Babar @82fb^{-1}
  hadronic and semileptonic tagging
  $Br(B \to K^+ \nu\bar{\nu}) < 5.2 \times 10^{-5}$ (90%C.L.)
- Belle @253fb^{-1}
  hadronic tagging
  $Br(B \to K^+ \nu\bar{\nu}) < 3.6 \times 10^{-5}$ (90%C.L.)
- Belle @492fb^{-1}
  hadronic tagging
  $Br(B \to K^{*0} \nu\bar{\nu}) < 3.4 \times 10^{-4}$ (90%C.L.)



Br(B



B→K$^+\nu\nu$ extrapolated sensitivity (if SM)

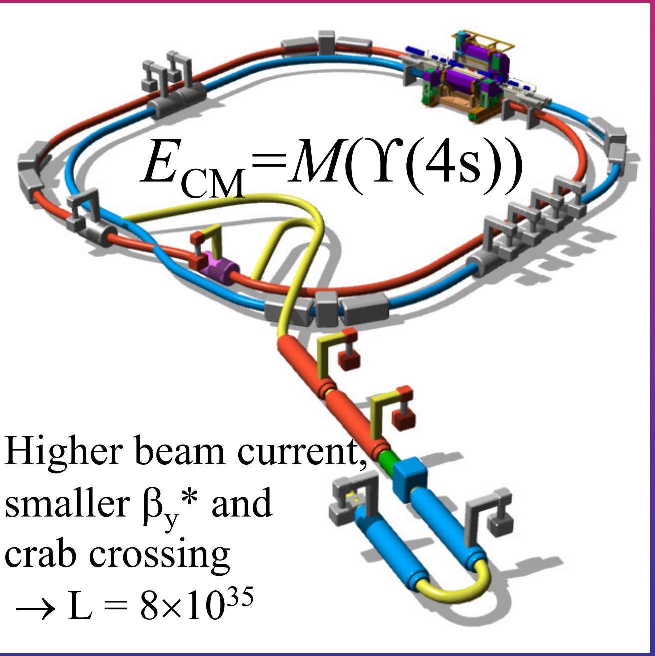
3σ @ 12ab^{-1}, 5σ @ 33ab^{-1}

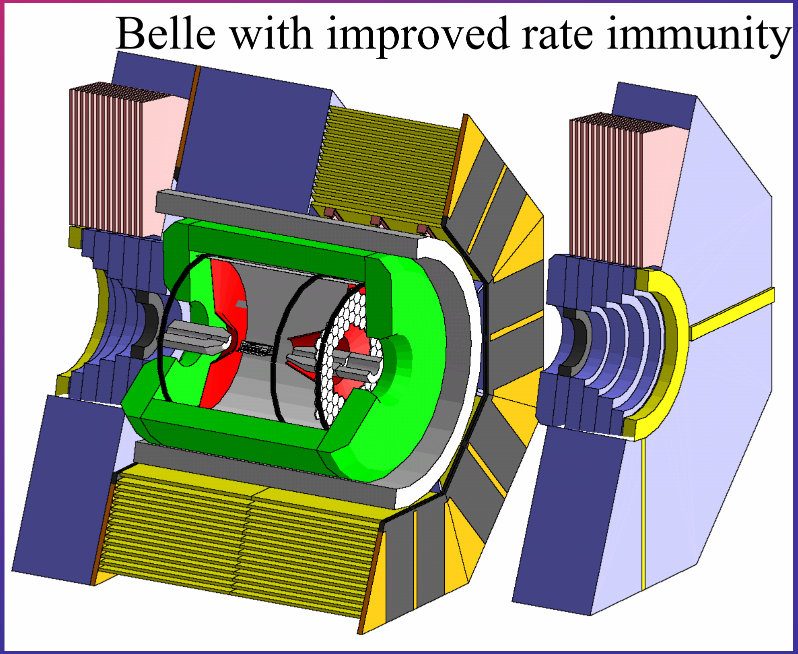
Need Super-B !!

SuperKEKB

- *Asymmetric-energy e^+e^- collider to be realized by upgrading the existing KEKB collider.*
- *Super-high luminosity $\simeq 8\times10^{35}\ cm^{-2}s^{-1} \rightarrow 10^{10}\ B\bar{B}$ per yr.*

  $\rightarrow 8\times10^{9}\ \tau^+\tau^-$ per yr.
- *Letter of Intent is available at:* http://belle.kek.jp/superb/loi

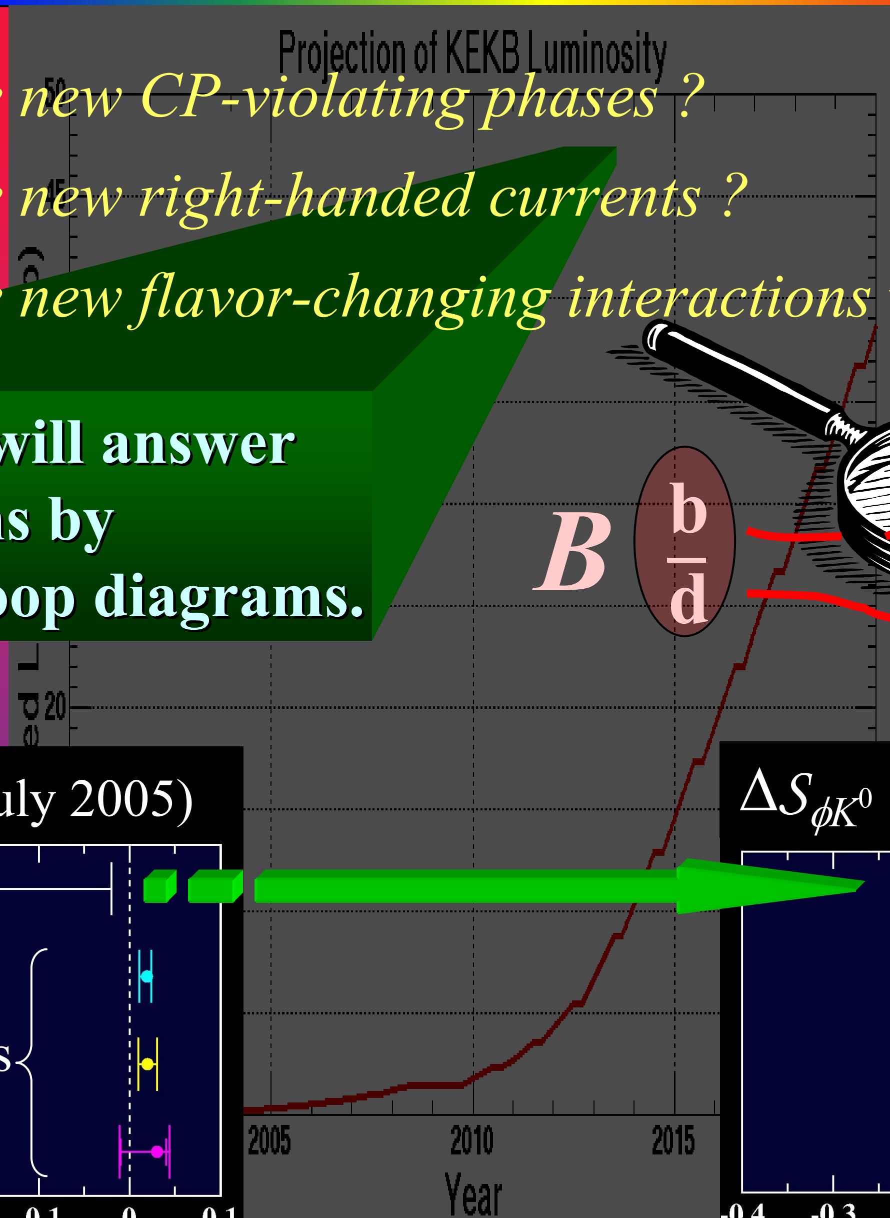


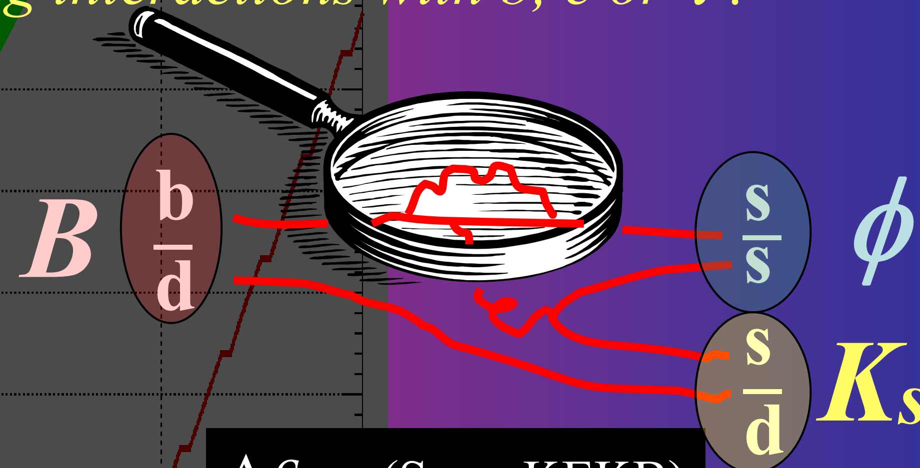


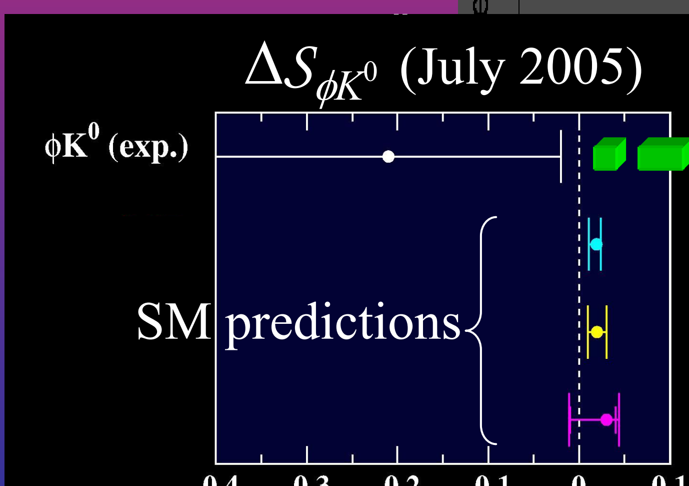
Flavor Physics at SuperKEKB

1. *Are there new CP-violating phases ?*
2. *Are there new right-handed currents ?*
3. *Are there new flavor-changing interactions with b, c or τ ?*

SuperKEKB will answer these questions by scrutinizing loop diagrams.



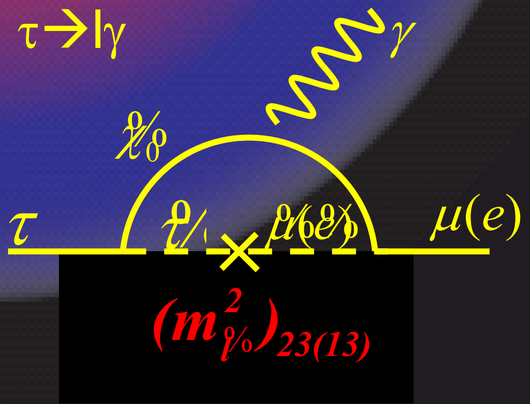




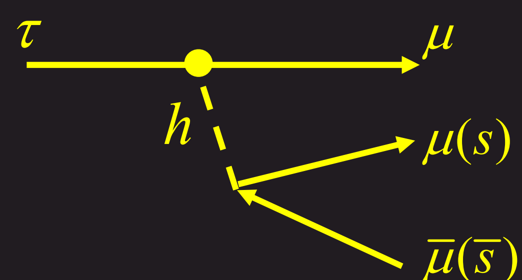
LFV Search at Super-B

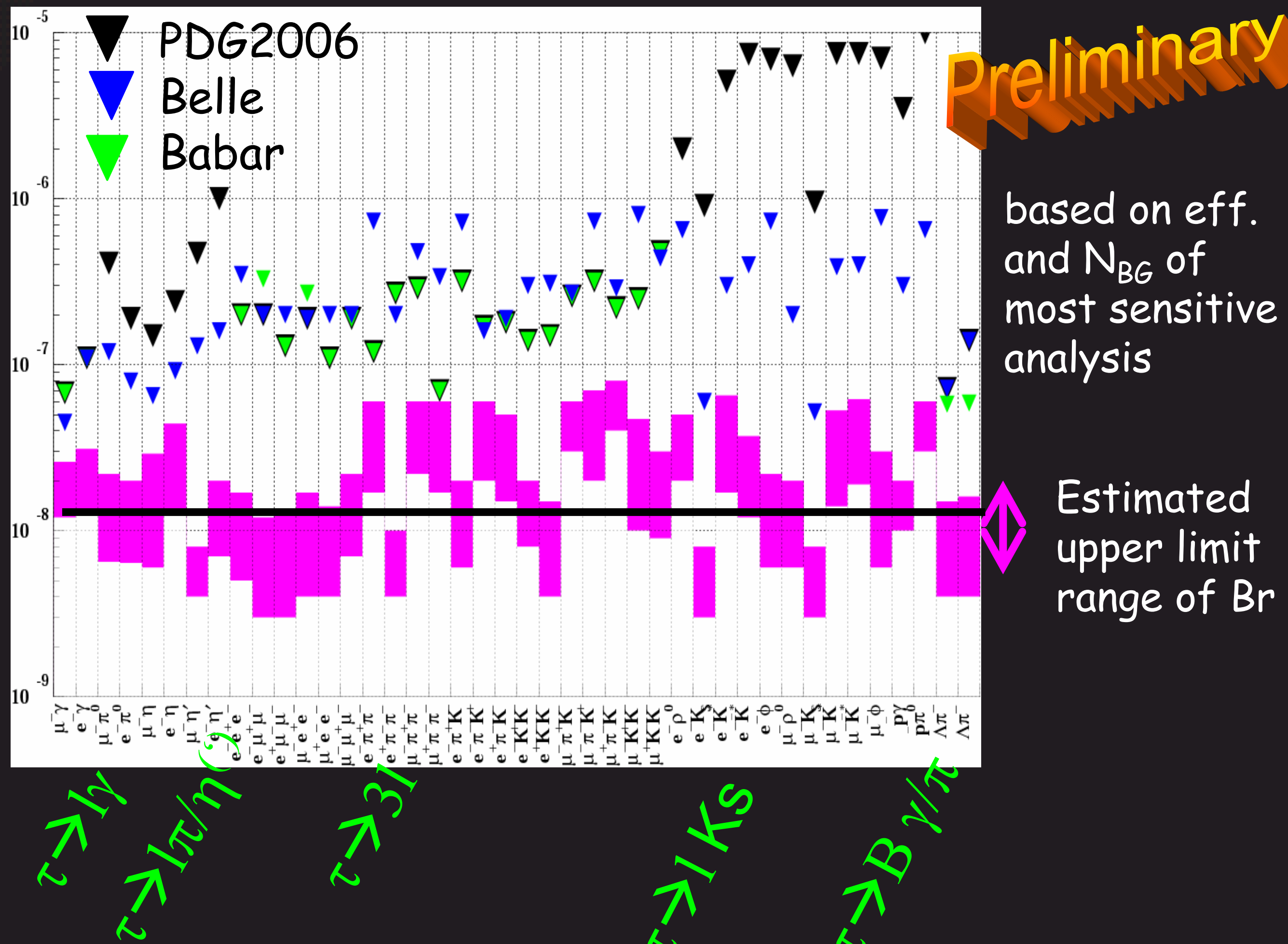
cf) Hayasaka at BNM2006

$\tau \to l\gamma$



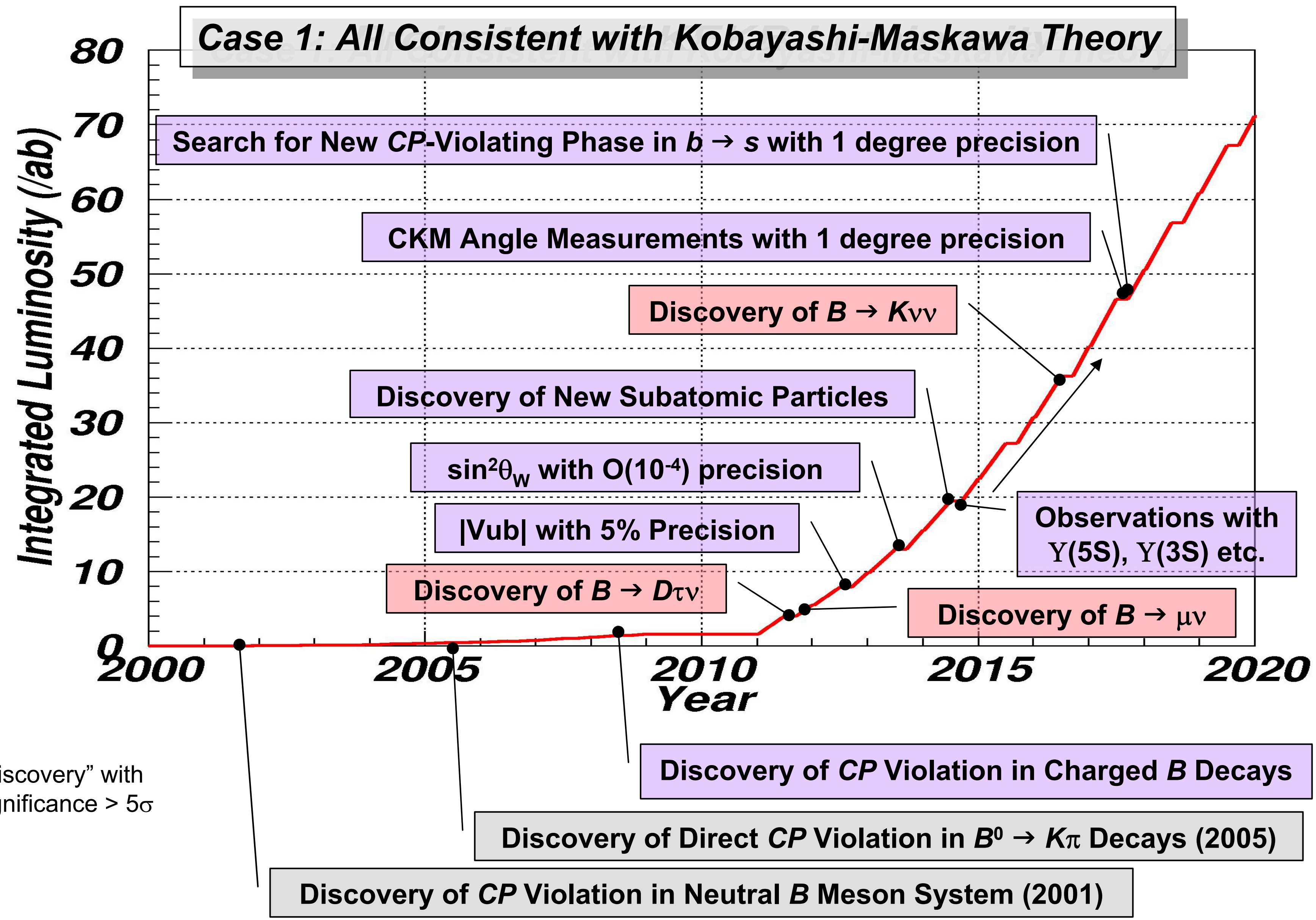
$\tau \to 3l$, $l\eta$





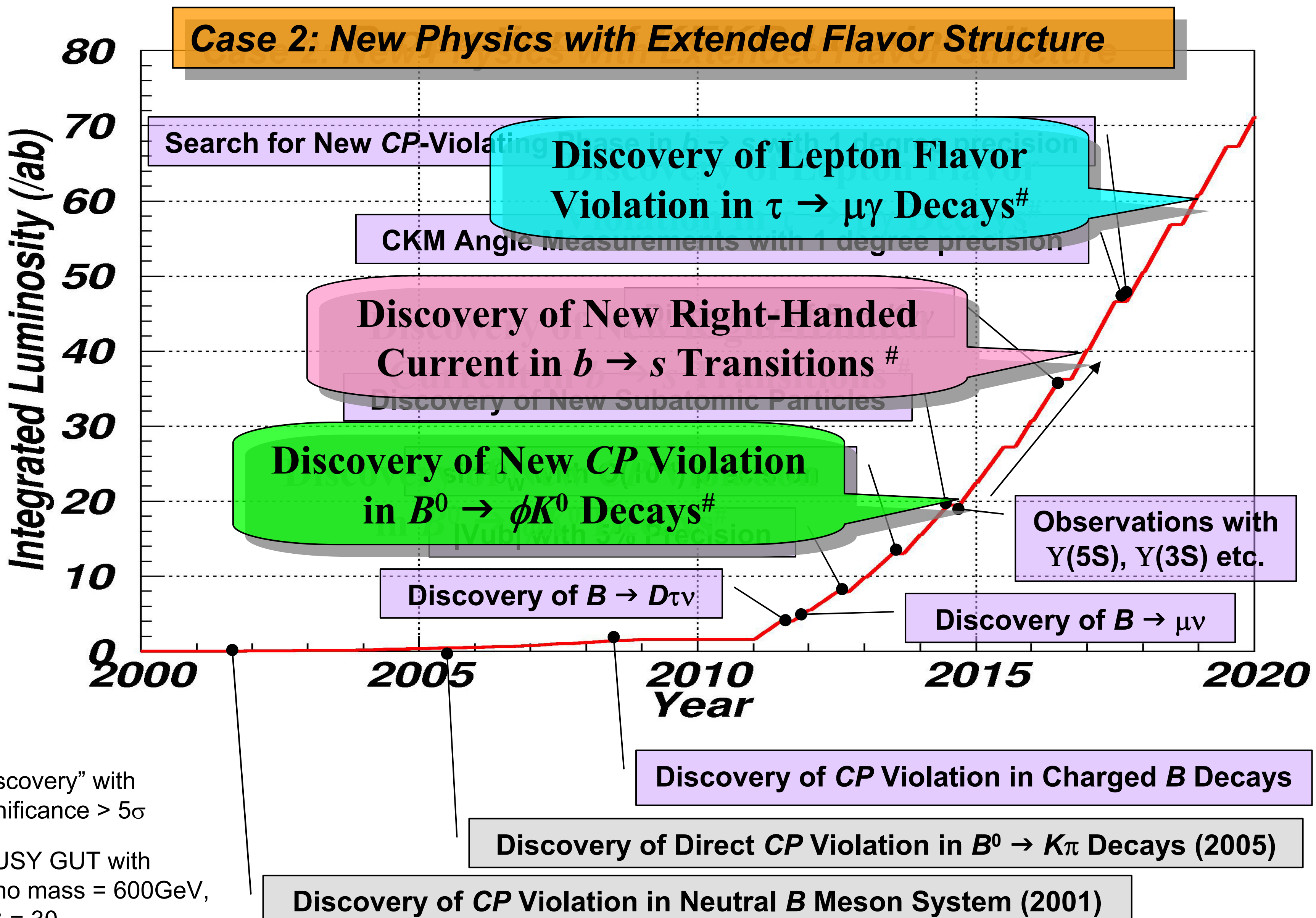
Search region enters into $O(10^{-8} \to 10^{-9})$

Major Achievements Expected at SuperKEKB



“Discovery” with significance > 5σ

Major Achievements Expected at SuperKEKB



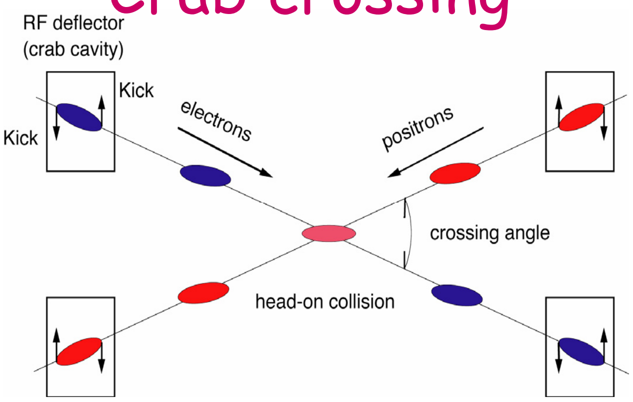
"Discovery" with significance > 5σ

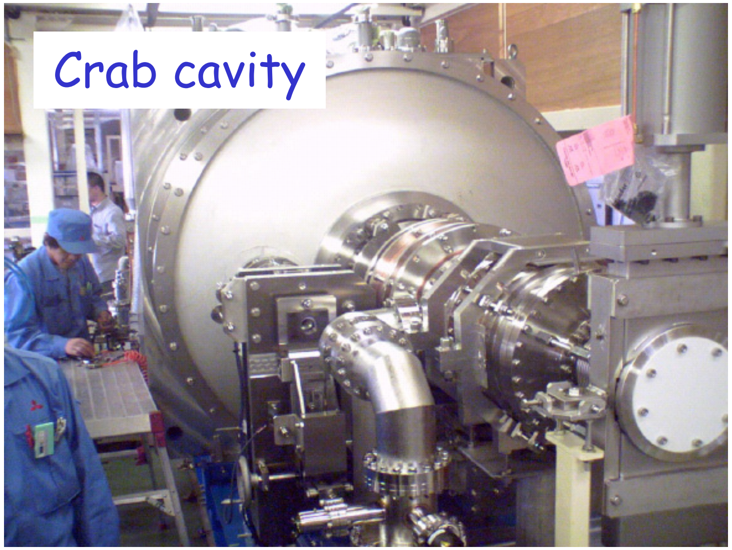
SUSY GUT with gluino mass = 600GeV, tanβ = 30

Super-KEKB Status

- Super-high luminosity ≅ 8×10^{35} $cm^{-2}s^{-1}$
  - Natural extension of KEKB
  - With technology proven at KEKB
- Many key components are tested at KEKB. Crab crossing will be tested in winter 2007.

Crab crossing





Super-KEKB is a machine which can be build now.

Super-KEKB Status

- Letter of Intent (LoI) in 2004
  - 276 authors from 61 institutions
  - available at http://belle.kek.jp/superb/loi
  - "Physics at Super B Factory" hep-ex/0406071

- Updates of physics reach and also new measurements (Υ(5S) run etc.) are extensively discussed.
  - BNM2006 workshop (Sep.13-14) http://www-conf.kek.jp/bnm/2006/
  - 2nd meeting at Nara (Dec.18-19, after CKM2006@Nagoya)

A lot of activities for physics and detector studies !
You are welcome to join !

Summary

- The first evidence of $B \to \tau\nu$ has obtained by Belle @414fb^{-1}.
  → Successful operation of B factories have finally brought the B leptonic decays on the stage.
- O(ab^{-1}) data will bring $B \to \mu\nu$ and $B_d \to \mu\mu$ for serious examination.
- These enable us to explore New Physics, esp. in large $\tan\beta$ region, together with other measurements; Δm_{Bs}, $B_s \to \mu\mu$, $B \to X_s\gamma$ and also τ decays ($\tau \to \mu\eta$, $\tau \to \mu\gamma$). (see talk by A.Weiler)
- O(10ab^{-1}) data will bring $B \to K\nu\nu$ at horizon.

We need a Super B Factory !

- Super-KEKB aims at $L = 8\times10^{35}\,cm^{-2}s^{-1}$, with tech. proven at KEKB.
- A lot of activities for physics and detector studies.
- HEP community in Japan is now discussing "Grand Lepton Collider" plan to accommodate both Super-KEKB and ILC.

Stay tuned !

References

- $B \to l\nu$
  - $B \to \tau\nu$: Belle (hep-ex/0604018), BaBar (hep-ex/0608019)
  - $B \to \mu\nu$, $e\nu$: Belle (hep-ex/0408132), BaBar (hep-ex/0607110)
  - $B \to l\nu\gamma$: Belle (hep-ex/0408132)

- $B \to ll$
  - $B \to e^+e^-$, $\mu^+\mu^-$, $e^+\mu^-$ Belle (PRD68, 111101(R) (2003)) BaBar (PRL94, 221803(2005)), CDF
  - $B \to e^+e^-\gamma$, $\mu^+\mu^-\gamma$: BaBar(hep-ex/0607058)
  - $B \to \tau^+\tau^-$: BaBar(PRL96, 241802 (2006))

- $B \to K\nu\nu$, $\nu\nu$
  - $B^+ \to K^+\nu\nu$ Belle(hep-ex/0507034), BaBar(PRL94, 101801 (2005))
  - $B^0 \to K^{*0}\nu\nu$ Belle(hep-ex/0608047)
  - $B^0 \to \nu\nu$ BaBar(PRL93, 091802(2004))

Due to limited time, some of them cannot be mentioned or have to be put in backup

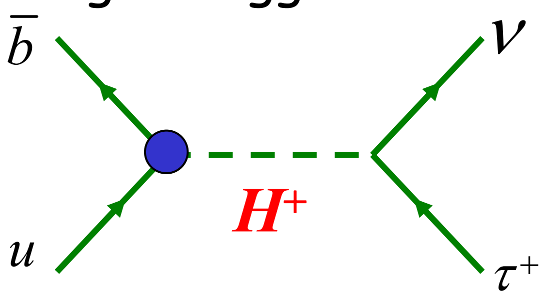
Backup

New Physics in large tanβ

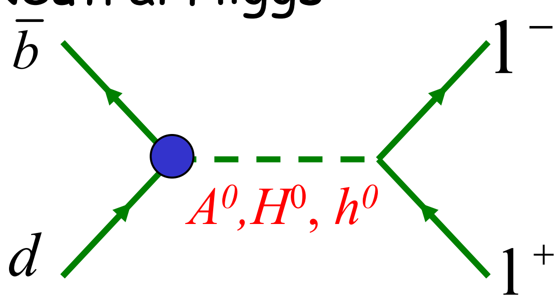
- Leptonic decays ($B \to l\nu$, ll) are theoretically clean, free from hadronic uncertainty.
- In particular, they are good probes in large tanβ region, together with other measurements; Δm_{BS}, $B_s \to \mu\mu$, $B \to X_s\gamma$ and also τ decays ($\tau \to \mu\eta$, $\tau \to \mu\gamma$).

Ex.) G.Isidori & P.Paradisi, hep-ph/0605012

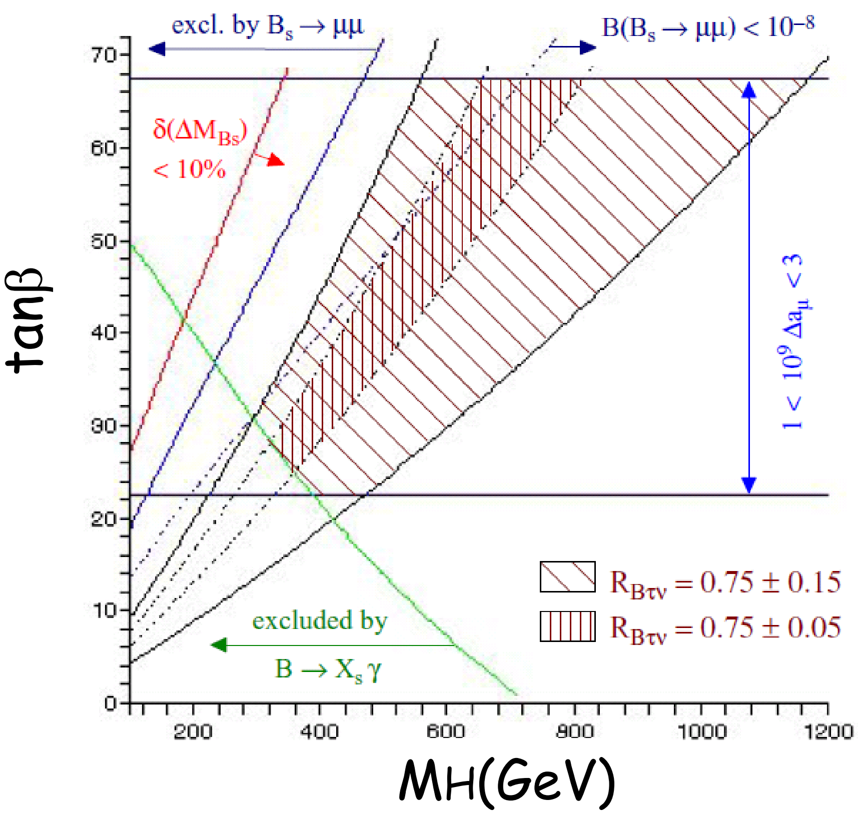
Charged Higgs



Neutral Higgs



See talk by A.Weiler



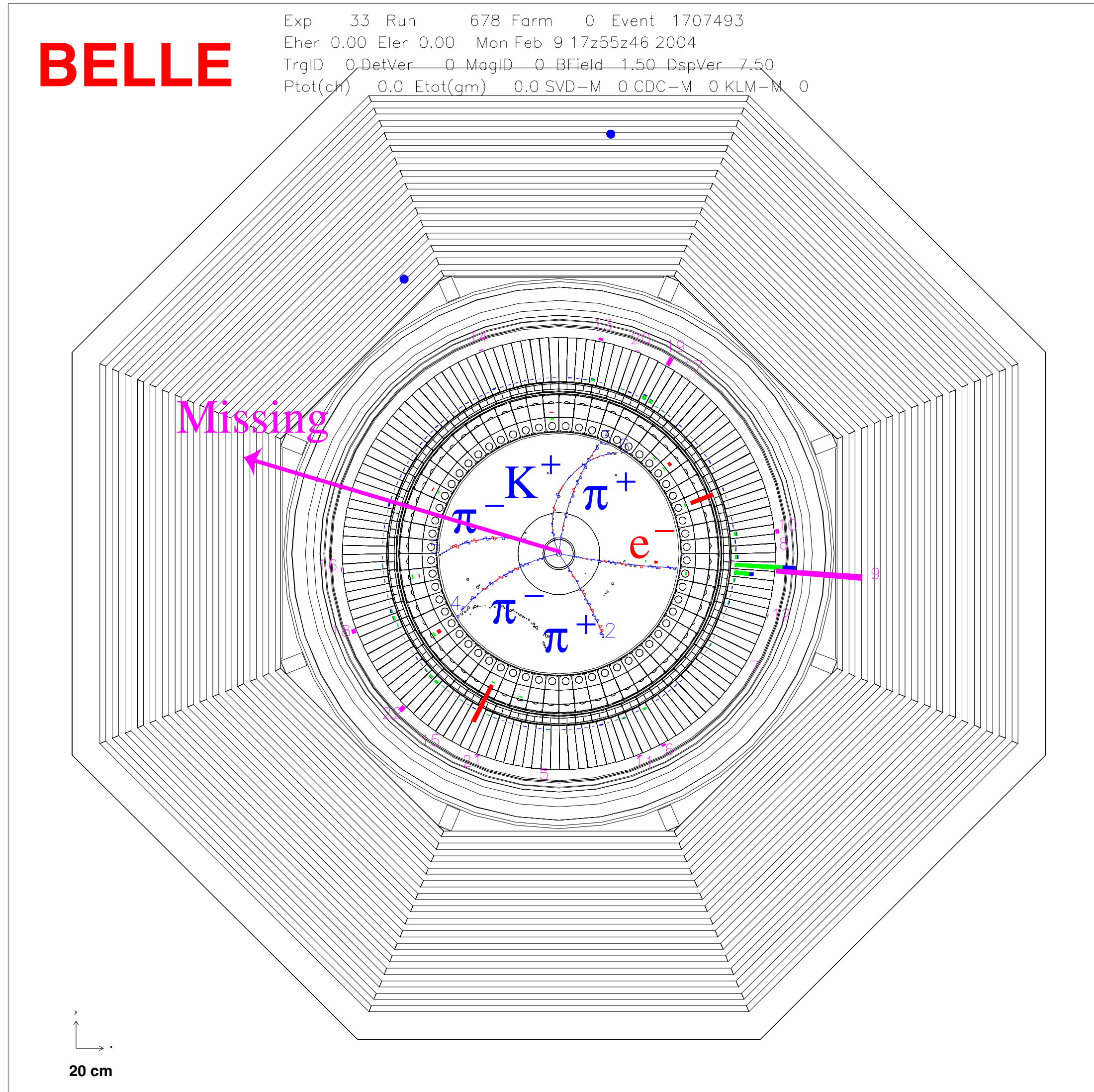
$B \rightarrow \tau\nu$ Candidate Event

$B^{+} \rightarrow \overline{D^{0}}\, \pi^{+}$

$\quad \hookrightarrow K^{+}\, \pi^{-}\, \pi^{+}\, \pi^{-}$

$B^{-} \rightarrow \tau^{-}\, \nu$

$\quad \hookrightarrow e^{-} \nu \nu$



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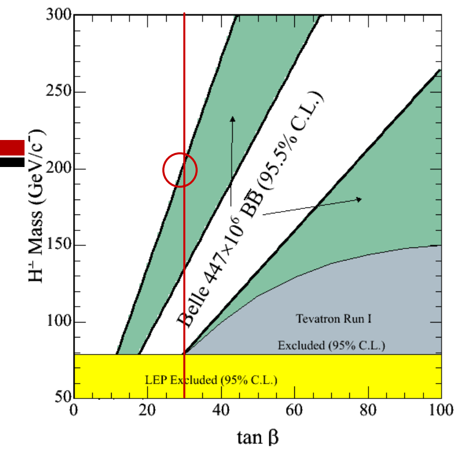
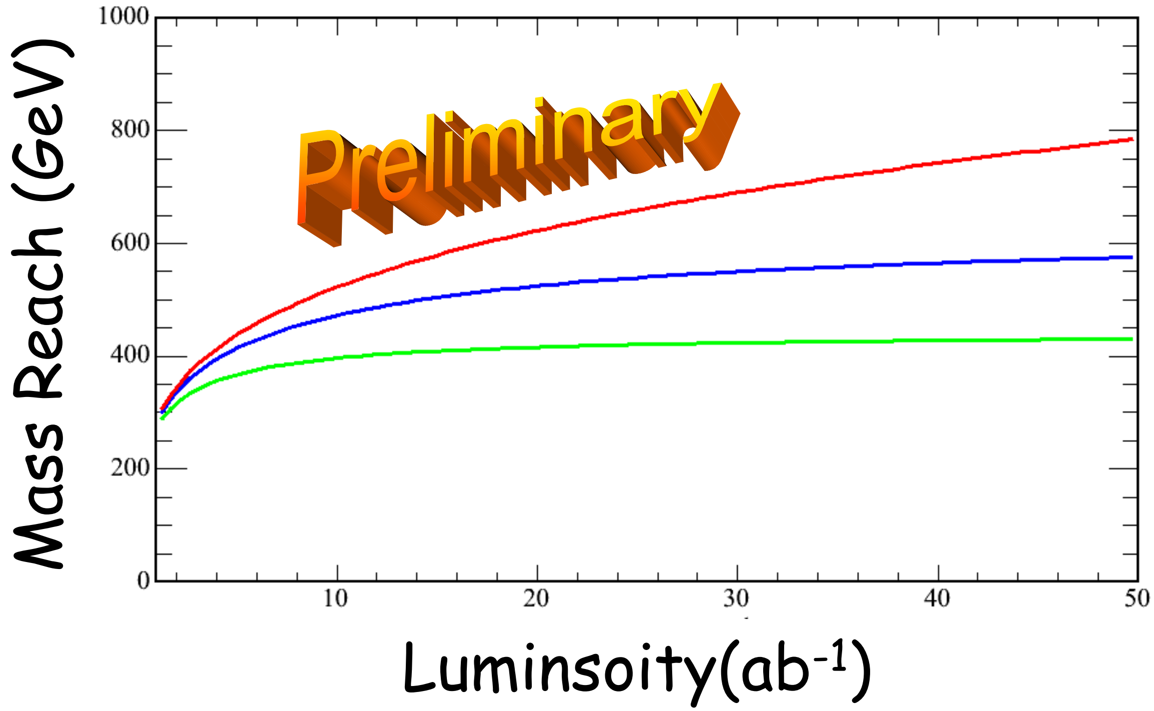


Charged Higgs Mass Reach
(95.5%CL exclusion @ tanβ=30)



Only exp. error (ΔV_{ub}=0%, Δf_B=0%)

ΔV_{ub}=2.5%, Δf_B=2.5%

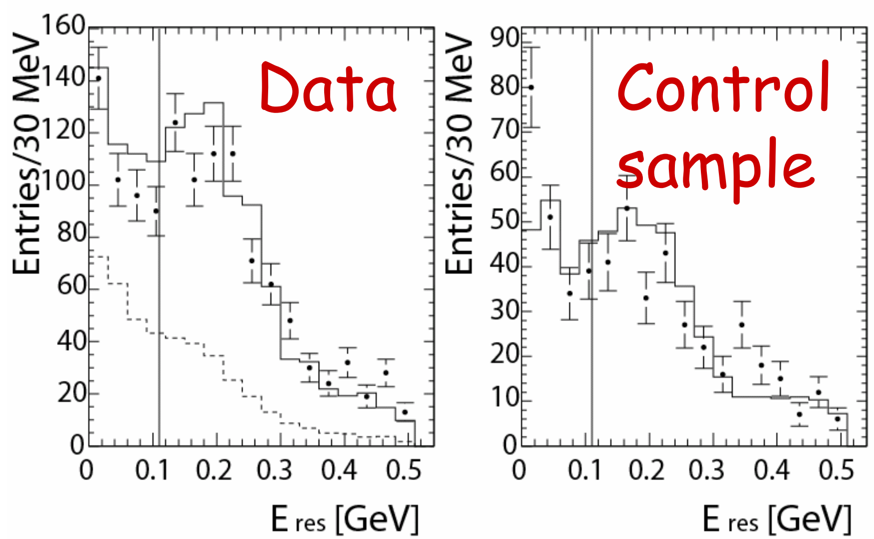
ΔV_{ub}=5%, Δf_B=5%

Note) Ratio to cancel out f_B may help (G.Isidori&P.Paradisi, hep-ph/0605012)

$$\frac{Br(B \to \tau\nu)}{\Delta m_d} \to \left|\frac{V_{ub}}{V_{td}}\right| \Longleftrightarrow \left|\frac{V_{ub}}{V_{td}}\right|$$ from other measurements

$B^0 \to \tau^+ \tau^-$ (BaBar @ 210fb^{-1})

- Experimentally very very challenging (2-4 neutrinos in the final state !)
- High sensitive to NP ⟺ $B_s \to \mu\mu$ at hadron machines



- Analysis
  - Reconstruct one B in a fully hadronic final state $B \to D^{(*)} X$ =>280k events
  - In the event remainder, look for two τ decays ($\tau \to l\nu\nu$, $\pi\nu$, $\rho\nu$)
  - Kinematics of charged partilce momenta and residual energy are fed into a neutral network to separate signal and BG

Nobs=263$\pm$19 ⟺ Nexpect=281$\pm$48

$$Br(B \to \tau\tau) < 4.1 \times 10^{-3} \quad @90\%C.L.$$

Phys. Rev. Lett. 96, 241802 (2006)

$B^0 \to \bar{\nu}\,\nu$ (invisible) @Babar

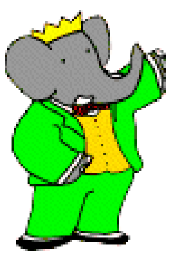
B pairs used: $(88.5 \pm 1.0) \times 10^6$

- **Semileptonic tags :**

  $B^0 \to D^{(*)-} l^+ \nu$ ($D^{*-} \to D^0 \pi^-$)
- **Require nothing in recoil:**
  - no charged tracks,
  - limited # of neutral clusters.
- **ML fit to E_{extra}**

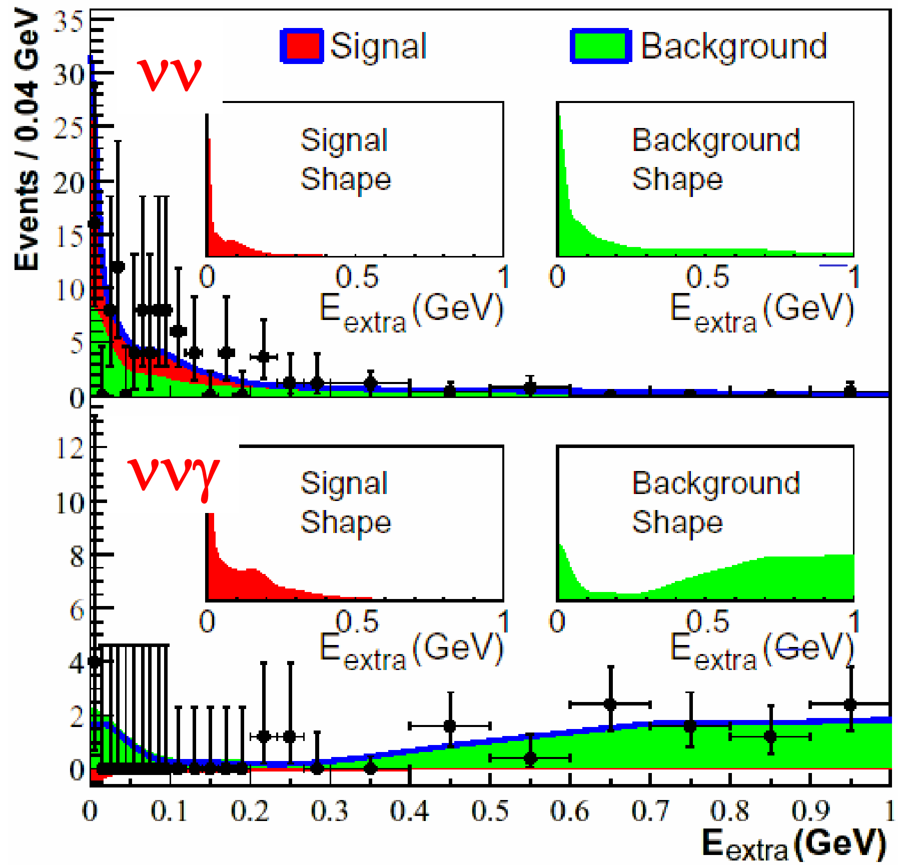
  $Ns = 17 \pm 9$

  $Nb = 19^{+10}_{-8}$



- **Upper limit (frequentist)**

  incl. systematics (additive;7.4events, multiplicative; 10.9%)



Phys. Rev. Lett. 93, 091802 (2004)

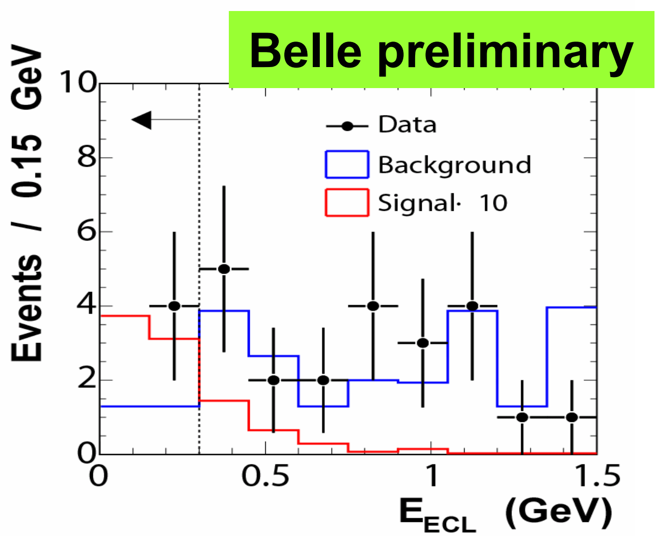
$B(B^0 \to \text{invisible}) < 22 \times 10^{-5}$ (90%CL)

Future Prospect: B→Kνν

- Belle @ 250fb^{-1} (preliminary)

cf.) K.Ikado @ BNM2006

Fully reconstructed tag (by modifying the PID criteria used in B→τν analysis).



Efficiency(%)	42.8 ± 1.8
Signal expected	0.70 ± 0.03
Background expected	2.6 ± 1.6
Observed Events	4

Consistent with BG expected

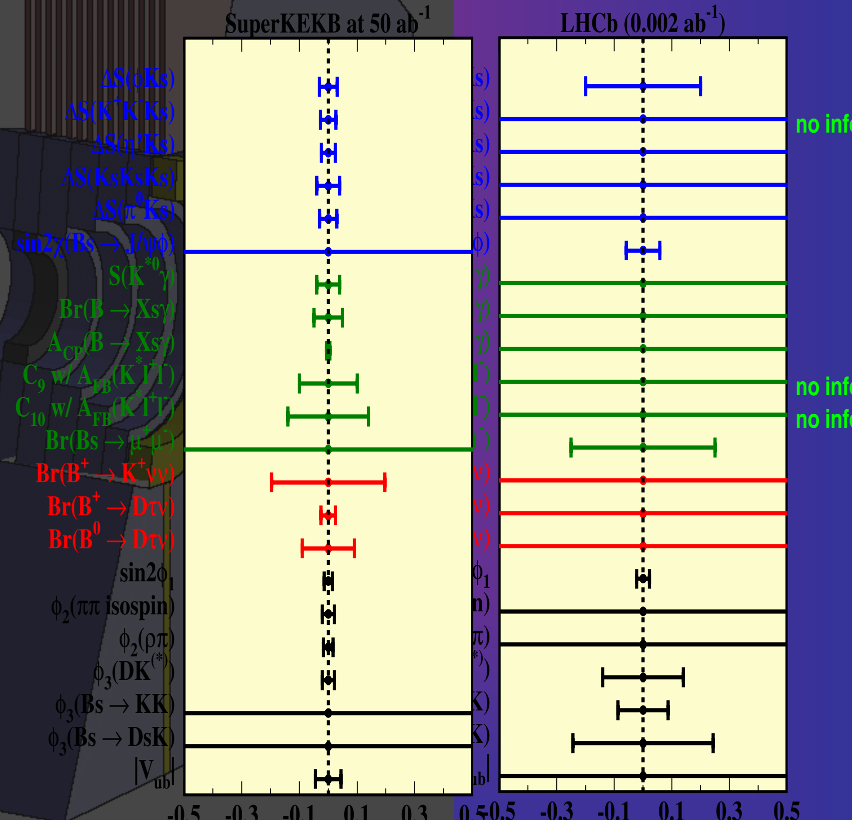
$$\mathcal{B}(B^+ \to K\nu\bar{\nu}) < 3.6 \times 10^{-5} (90\%\text{C.L.})$$

Signif.	Lum (ab^{-1})
3σ	12
5σ	33

Need Super-B !

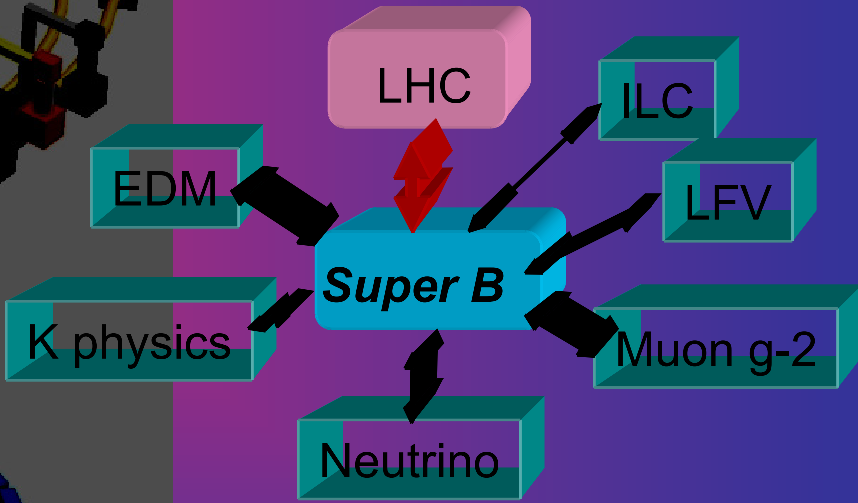
Advantages of SuperKEKB

- Clean environment → measurements that no other experiment can perform.
  Examples: CPV in $B \to \phi K^0$, $B \to \eta' K^0$ for new phases, $B \to K_S \pi^0 \gamma$ for right-handed currents.
- "***B***-meson beam" technique → access to new decay modes.
  Example: discover $B \to K \nu \bar{\nu}$.
- Measure new types of asymmetries.
  Example: forward-backward asymmetry in $b \to s\mu\mu$, ***see***
- Rich, broad physics program including ***B***, τ and charm physics.
  Examples: searches for $\tau \to \mu\gamma$ and D-$\bar{D}$ mixing with unprecedented sensitivity.
- **No other experiment can compete for New Physics reach in the quark sector.**



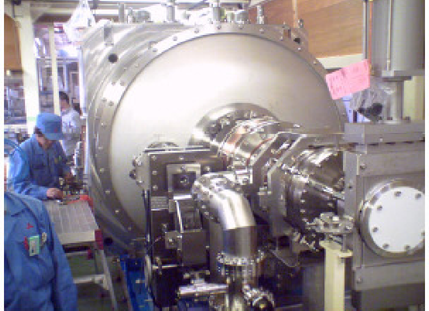
Role of SuperKEKB

- *What is the origin of CP violation ?*
- *What is the origin of the matter-dominated Universe ?*
- *What is the flavor structure of new physics (e.g. SUSY breaking) ?*



These grand questions can only be answered by experiments both at the luminosity and energy frontiers. SuperKEKB will play an essential role.

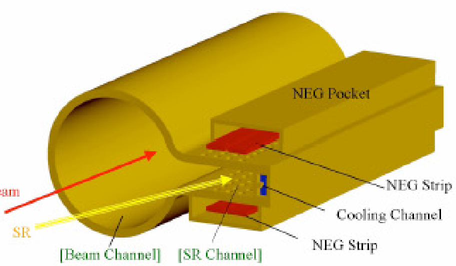
SuperKEKB

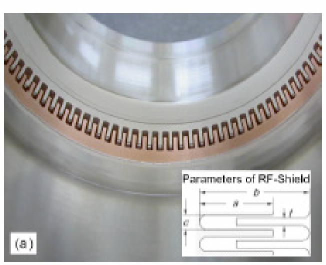


Crab cavities will be installed and tested with beam in 2006.

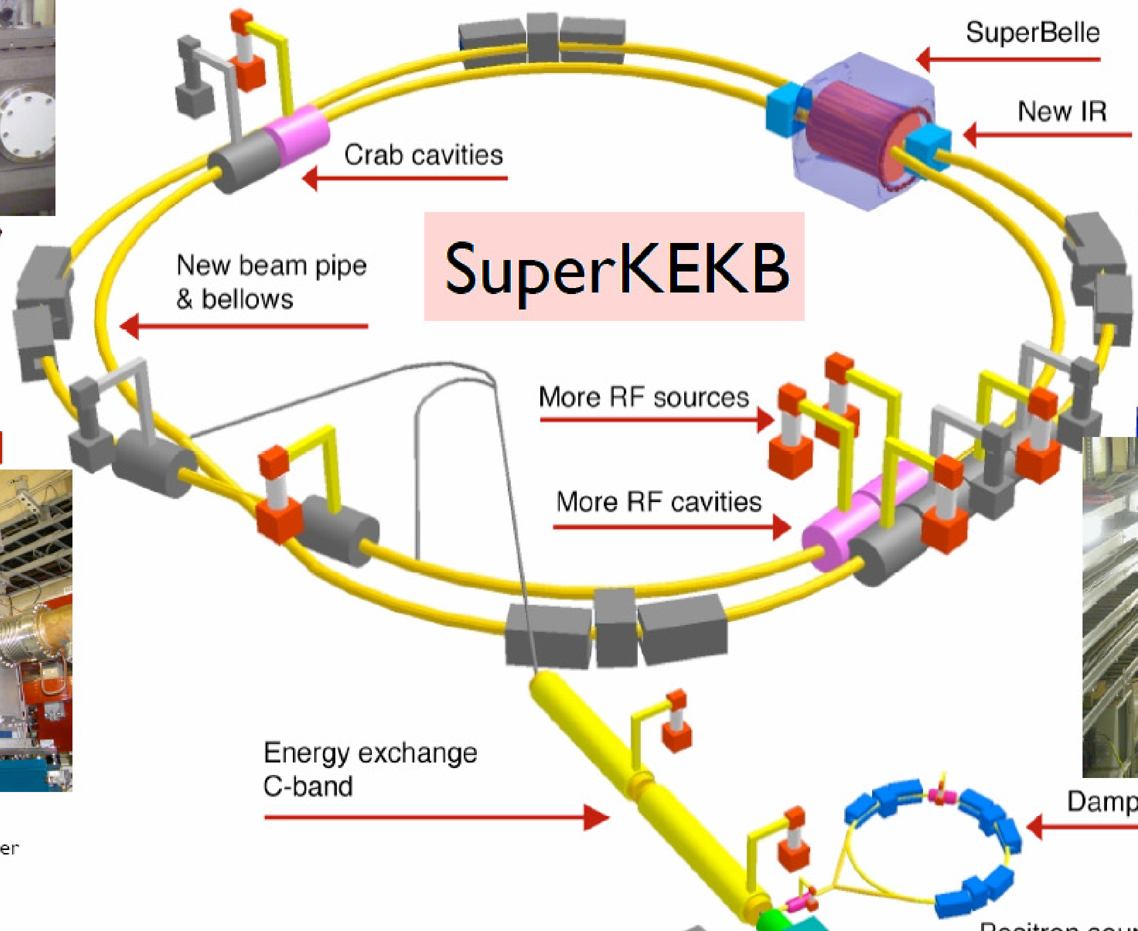
e+ 4.1 A

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





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



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

e- 9.4 A

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

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

will reach 8×10^{35} cm^{-2}s^{-1}.