Super B Factories

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Disclaimer: this talk is somewhat biased towards SuperKEKB
B-factories — Glory, or Nightmare?

- Discovery of CP violation in $B$ decays, CKM fully established
  Possible by 100x more data (+ CM-boost)

- Yet many questions in the SM (hierarchy problem, origin of CKM, ...)
  something beyond SM must be there (but why not seen?)

WANTED: 100x more data, again
Effective BSM contribution?

Unitarity triangle
CKM only and CKM+BSM

Box and Penguin (CKM + BSM)

Tree (CKM only)
Need ultimate luminosity + theory improvements + some luck (note: based on the ultimate optimistic error estimates)
More key measurements

- **Precision CKM test**: tree \( (\phi_3, V_{ub}) \) vs loop \( (\phi_1, \phi_2, V_{td}) \)

- **Non-SM CP phase**: tCPV in \( b \to s \) penguin
  \( (B \to \phi K_S^0, B \to \eta' K_S^0 \text{ at Super B} \iff B_s \to \phi \phi \text{ at LHCb}) \)

- **Non-SM right-handed current**: \( B \to K^*\gamma \text{ tCPV} \ (\iff B_s \to \phi \gamma) \)

- **Charged Higgs**: searches in \( B^+ \to \tau^+\nu \) and \( B \to D^{(*)}\tau^+\nu \)

- **Inclusive measurements**: \( b \to s\gamma, b \to d\gamma, b \to s\ell^+\ell^- \ (A_{FB}), V_{ub} \)

- **Lepton flavor violation**: searches in high statistics \( \tau \) decays
  \( \text{(no counterpart at LHCb)} \)

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**Modes with photon(s)**
**Modes with \( \pi^0 \)**
**Modes with neutrino**

\( \text{are crucial} \)
\[ A_{CP}(\Delta t) = -\xi_f S \sin(\Delta m \Delta t) + \mathcal{A} \cos(\Delta m \Delta t) - C \]
CPV in box + tree vs box + penguin

Complex interference term at $t \neq 0$ due to the weak phase difference,

$$\phi_1 = \pi - \arg(V_{tb}^* V_{td} / V_{cb} V_{cd}^*)$$

Golden mode $B \to J/\psi K^0$

$$\delta(\sin 2\phi_1) \sim 0.01 \text{ (syst. limited)}$$

with a few ab$^{-1}$ ($\delta_{\text{theo}} \sim 0.01$)

Platinum modes:

- $B^0 \to \phi K^0$
- $B \to \eta' K^0$
- $B \to K_S^0 K_S^0 K_S^0$

(Super B Factories — M. Nakao — p.7)
$b \to s$ CPV Projection

- $S_{\phi K^0} \neq \sin 2\phi_1$ — easy to establish for current central values
- Statistical error dominated till $\sim 50 \text{ ab}^{-1}$, final $\delta S \sim 0.02–0.03$
$\phi_2$ from $B \to \pi\pi, \rho\pi, \rho\rho$

- $S = \sin 2\phi_2$ if no penguin pollution
- Isospin analysis — measure all branching fractions and $A_{CP}$ for $B^0 \to \pi^+\pi^-$, $B^0 \to \pi^0\pi^0$ and $B^\pm \to \pi^\pm\pi^0$ (Dalitz for $B \to \rho\pi$)

\[ B \to \pi\pi \]

\[ B \to \rho\pi \]

\[ B \to \rho\rho \]

1 - C.L.

$\phi_2$ (degrees)
**φ₁ and combined φ₂**

- **φ₂ combined**: $2°$ error ($5 \text{ ab}^{-1}$)
  - ($1°$ error ($50 \text{ ab}^{-1}$))
  - if all results align
- **Theory (isospin) error**: $\sim 2°$ in addition

**Reference point on $(\bar{\rho}, \bar{\eta})$!**

($δ \sin 2φ₁ = 0.016$, $φ₁ = 21.4°$, $φ₂ = 90°$ at $5 \text{ ab}^{-1}$)

Free from LQCD!
Methods

- $t$CPV of $B \rightarrow D^{\pm\mp} \pi^\mp (\sin(2\phi_1 + \phi_3))$
- $B^\pm \rightarrow D_{CP}K^\pm$ (GLW method)
- $B^\pm \rightarrow D_{DCSD}K^\pm$ (ADS method)
- $B^\pm \rightarrow D^0K^\pm$, $D^0 \rightarrow K_S^0\pi^+\pi^-$ Dalitz analysis

<table>
<thead>
<tr>
<th></th>
<th>5 ab$^{-1}$</th>
<th>50 ab$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B \rightarrow D^{\pm\mp} \pi^\mp$</td>
<td>18°</td>
<td>6°</td>
</tr>
<tr>
<td>GLW + ADS</td>
<td>16°</td>
<td>5°</td>
</tr>
<tr>
<td>Dalitz</td>
<td>7°</td>
<td>2.5°</td>
</tr>
<tr>
<td>All combined</td>
<td>6°</td>
<td>2°</td>
</tr>
</tbody>
</table>

(depending on the value of $r$)

(need charm-factory data)

(cf. LHCb (10 fb$^{-1}$ / 2013) — $\delta\phi_3 \sim 2^\circ$ from $D_sK$ (5°), ADS (4°), GLW (4°), Dalitz (5°))
$V_{ub}$ (inclusive measurement)

$|V_{ub}| = (3.98 \pm 0.15_{\text{exp}} \pm 0.30_{\text{theo}}) \times 10^{-4}$

(Jan. 7, 2008 HFAG)

$8.3\% = \pm 2.0_{\text{stat}} \pm 2.5_{\text{exp}} \pm 1.8_{b2cmodel} \pm 1.1_{b2umodel} \pm 6.3_{\text{HQEparam}} \pm 0.4_{\text{SFfunc}} \pm 0.7_{\text{subSF}} \pm 3.6_{\text{matching}} \pm 1.4_{\text{WA}}$

- HQE parameters to be reduced from $b \rightarrow c\ell^-\bar{\nu}$

Need to include higher $M_X$ to reduce theory error
Not really stat. limited!
Larger dataset will help to study $b \rightarrow c$ background
(theory field is also VERY active)

$V_{ub}$ from exclusive will improve, too, provided LQCD improves
**Unitarity Triangle at 50 ab$^{-1}$**

- $V_{ub}$ from inclusive $b \rightarrow u\ell^-\bar{v} \Rightarrow \delta = 4\%$
- $\phi_3$ from $B \rightarrow DK \Rightarrow \delta = 2^\circ$ with 50 ab$^{-1}$
- A super B-factory alone can discriminate tree vs loop
- Improvements in Lattice QCD will further reduce errors ($V_{ub}$ from exclusive, $V_{td}$ from $B \rightarrow \rho\gamma$)

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Errors for 50 ab$^{-1}$ (with no LQCD info)

Central values from 2007 averages
Next Generation B Factory

- Integrated luminosity of the order of \(50 \text{ ab}^{-1}\) is needed
- Luminosity of the order of \(10^{36} \text{ cm}^{-2}\text{s}^{-1}\) is needed
- **Super Flavor factory** — \(B, \tau\) and charm physics at \(\Upsilon(4S)\) (also option to run at different energies)
- To be operated in 2010s (synergy with LHCb and LHC)
- Two approaches pursued (desirable to have both, if ¥€$ allows)

**SuperKEKB** (Japan)
- Crab cavities for head-on collision
- Higher beam currents / higher power
- Straightforward upgrade of existing machine

**SuperB** (Italy)
- Radical new approach with a new machine
- Ultra-small beam spot (ILC damping-ring like)
- Large crossing angle and "crab waist"
The Master Formula

Lorentz factor

Classical electron radius

Beam size ratio

Beam current

1.7×1.4/3.2×2.1 (KEKB/PEP-II)
→ 9.4×4.1 A (SuperKEKB)
→ 1.85×1.85 A (SuperB)

Beam-beam parameter

0.059 (KEKB)
→ >0.24 (SuperKEKB)
→ 0.15 (SuperB)

Luminosity

0.017×10^{36} \text{ cm}^{-2}\text{s}^{-1} (KEKB)
→ 0.8×10^{36} \text{ cm}^{-2}\text{s}^{-1} (SuperKEKB)
→ 1×10^{36} \text{ cm}^{-2}\text{s}^{-1} (SuperB)

Geometrical factors due to crossing angle and hour-glass effect

Vertical $\beta$ at the IP

6.5/5.9 mm (KEKB)
→ 3.0/3.0 mm (SuperKEKB)
→ 0.22/0.39 mm (SuperB)
Crab cavity (KEKB/SuperKEKB)

- Finite crossing (22 mrad) → effective head-on collision
- Beam-beam force become nearly independent on $x$ at horizontal half integer tune $\xi_y \sim 0.15$ for KEKB-crab and twice more $L$ ($\xi_y > 0.24$ for SuperKEKB-crab)
- Enhancement is seen, $\xi_y = 0.092$ (no crab: $\xi_y = 0.056$)

Luminosity drop for high current is being investigated.
Crab cavities to be upgraded for a higher current

Antechamber beampipes and higher-current-proof bellows

Superconducting cavities to absorb more HOM power up to 50 kW

ARES RF cavities with higher energy storage ratio

\[ \beta_y^* = \sigma_z = 3\text{mm} \]

\[ e^+ 4.1\text{ A} \]

\[ e^- 9.4\text{ A} \]

for \( 8 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1} \) (K.Oide)
KEK roadmap

- KEK’s 5-year roadmap, 3-year KEKB upgrade (‘09–’11) with constant annual budget (i.e., KEKB running cost → construction)
- Staging RF cavities and others, initial \( L \sim 2 \times 10^{35} \text{ cm}^{-2}\text{s}^{-1} \)
- Not actually funded yet, KEK management in close contact with the funding agency (MEXT)

A very realistic scenario with a 0.5–1 year delay (KEKB will run in 2009)

<table>
<thead>
<tr>
<th>Year</th>
<th>Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>J-PARC</td>
</tr>
<tr>
<td>2008</td>
<td>KEKB</td>
</tr>
<tr>
<td>2010</td>
<td>PF/PF+AR</td>
</tr>
<tr>
<td>2012</td>
<td>LHC</td>
</tr>
<tr>
<td>2014</td>
<td>R&amp;Ds for Advanced Accelerator and Detector Technology</td>
</tr>
</tbody>
</table>

- Detector R&D
- ERL
- C-ERL R&D
- ILC
- ILC R&D
- Host and Site: Yet to be decided

Very Preliminary
Crab waist (SuperB)

- Very small beam spot and $\beta^*_y$, a la LC damping ring
- Very small $\beta^*_y \Rightarrow$ demands
  - a very short bunch length (hourglass effect)
  - or crab waist

$\gamma$ waist can be moved along z with a sextupole on both sides at proper phase — “crab waist”

- Successful conceptual test at DAΦNE
SuperB site

- Site: INFN Rome Tor Vegarta campus
- Reuse: magnets will be brought from PEP-II
Detector Considerations

- **Background issue**
  - Much larger background is expected
  - Performance drop (esp. for photons) is not acceptable

- **Beam energy asymmetry**
  - Smaller asymmetry for lower electricity bill (for SuperB)
  - Also better for hermeticity, but worse for time-dep. CPV (unchanged for SuperKEKB)

- Existing detectors are excellent, no drastic performance difference after improving them to be capable for high background
Background issues

SuperBelle

- Higher beam current
- Large beam-gas background
- Moderate Touschek background
- Radiative-bhabha (luminosity term) is not dominant except KLM
- \( \times 20 \) background at full spec

 significant modification to Belle is needed

SuperB

- Beam-gas background is moderate
- Huge Touschek background
- Very short beam lifetime

 small modification to BaBar is sufficient

(note: BaBar is already much immune to beam backgrounds)
SuperBelle (baseline)
SVD: 6 layer (pixel?)
CDC: small cell, larger R
PID: TOP + ARICH
ECL: partially pure CsI
KLM: Scint.+ Si PM + new electronics

Current Belle
SVD: 4 layer
PID: ACC + TOF
ECL: All CsI(Tl)
KLM: RPC
SuperB detector (baseline)
reuse of BaBar
new SVT
new DCH
new fwd EMC
new IFR

(optional)

new components in green
Activities

SuperB group meeting last week
(http://www.pi.infn.it/bfactory/SuperB_elba2008/)

SuperKEKB meeting next month
(http://superb.kek.jp/inaug/)

May 2008 SuperB Meeting
La Biodola, Isola d'Elba
May 31st-June 3rd, 2008

Inaugural Meeting
3-gokan seminar hall, KEK, Japan / July 3rd and 4th, 2008

Open meeting for the proto-collaboration

Registration
Online registration is available.
Summary

- Physics at super B-factories are very compelling, in the integrated luminosity range 5–50 ab$^{-1}$
- Precise $\phi_2$ ($\delta = 2^\circ$) provides a reference point ($\bar{\rho}, \bar{\eta}$), BSM from tree measurements and $b \rightarrow s$ penguin
- Extensive searches for charged Higgs, RH current, LFV...
- Many other physics not discussed here

- Will we have a super B factory?
  - Accelerator and detector R&D are very active
  - SuperKEKB finalizing for production
  - SuperB design is getting converged
  - Probability for SuperKEKB is getting reasonably high
  - And, why don’t you join us?
Backup
## Parameter comparison

<table>
<thead>
<tr>
<th></th>
<th>SuperKEKB</th>
<th>SuperB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LER ($e^+$)</td>
<td>HER ($e^-$)</td>
</tr>
<tr>
<td>Energy (GeV)</td>
<td>3.5</td>
<td>8</td>
</tr>
<tr>
<td>Luminosity ($10^{36}$)</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Number of bunches</td>
<td>5018</td>
<td></td>
</tr>
<tr>
<td>Beam current (A)</td>
<td>9.4</td>
<td>4.1</td>
</tr>
<tr>
<td>$\beta(y^*)$ (mm)</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>$\beta(x^*)$ (mm)</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>emittance $\epsilon(y)$ (pm.rad)</td>
<td>60</td>
<td>66</td>
</tr>
<tr>
<td>emittance $\epsilon(x)$ (nm.rad)</td>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>beam-size $\sigma(x^*)$ (µm)</td>
<td>37.5</td>
<td>39.8</td>
</tr>
<tr>
<td>beam-size $\sigma(y^*)$ (µm)</td>
<td>2.11</td>
<td>2.28</td>
</tr>
<tr>
<td>bunch length</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Damping time (trans/long) (ms)</td>
<td>84/-</td>
<td>47/-</td>
</tr>
<tr>
<td>Touschek lifetime (min)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Effective beam lifetime (min)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>tune-shift $\xi(y)$ (from formula)</td>
<td>0.296</td>
<td></td>
</tr>
<tr>
<td>tune-shift $\xi(x)$ (from formula)</td>
<td>0.153</td>
<td></td>
</tr>
<tr>
<td>RF power (MW)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
MSSM down-type squark mass matrix

\[
\begin{pmatrix}
    m_{\tilde{d}_L}^2 & m_d (A_d - \mu \tan \beta) & (\Delta^d_{12})_{LL} & (\Delta^d_{12})_{LR} \\
    m_{\tilde{d}_R}^2 & (\Delta^d_{12})_{RL} & (\Delta^d_{12})_{RR} & \\
    m_{\tilde{s}_L}^2 & m_s (A_s - \mu \tan \beta) & (\Delta^d_{23})_{LL} & (\Delta^d_{23})_{LR} \\
    m_{\tilde{s}_R}^2 & (\Delta^d_{23})_{RL} & (\Delta^d_{23})_{RR} & m_{\tilde{b}_L}^2 \\
    m_{\tilde{b}_R}^2 & m_b (A_b - \mu \tan \beta) & & \\
\end{pmatrix}
\]

mass insertion approximation (MIA): \( (\delta^d_{ij})_{AB} = \frac{(\Delta^d_{ij})_{AB}}{\tilde{m}^2} \)

measured at LHC/LC

- **b → s transition** \((ij = 23)\)
  - CPV phase in \(b \rightarrow s\)
  - \(B \rightarrow X_s \gamma\) branching fraction
  - \(B_s\) mixing

- **b → d transition** \((ij = 13)\)
  - CPV phase in \(b \rightarrow d\)
  - \(B \rightarrow X_d \gamma\) branching fraction
  - \(B_d\) mixing
**Inclusive** $b \to s\gamma$

Most stringent BSM constraints — $\delta(\text{exp}) \sim \delta(\text{theo}) \sim 7\%$

\[
\mathcal{B}(B \to X_s\gamma; 1.6 \text{ GeV}) = (3.52 \pm 0.23 \pm 0.09) \times 10^{-4} \text{ (new HFAG average)}
\]

\[
\mathcal{B}(B \to X_s\gamma; 1.6 \text{ GeV}) = (3.15 \pm 0.23) \times 10^{-4} \text{ (SM NNLO Misiak et al)}
\]

- We’ve just learned that the full B-factory dataset is still statistical error limited
- Fully inclusive $B \to X_s\gamma$
- Full Belle dataset (605 fb$^{-1}$)
- $E_{\gamma}^{\text{min}} = 1.7 \text{ GeV}$

Still a super B-factory topic if we’d like to go down to lower $E_{\gamma}$

- Direct CPV in $B \to X_s\gamma$ — 0.4\% in SM, can reach this sensitivity
- Direct CPV in $B \to X_{s+d}\gamma$ — even small in SM, SUSY, \ldots
Exclusive $b \rightarrow s\gamma$

- CPV: sensitive to the non-SM right handed current
- SM CPV is suppressed ($S \sim -\frac{2m_s}{m_b} \sin 2\phi_1 = \text{a few \%}$), while e.g., $\delta^d_{RL}$ and $\delta^d_{RR}$ in MSSM will enhance it
- $B \rightarrow K^0_S\pi^0\gamma$ — extrapolate $K^0_S \rightarrow \pi^+\pi^-$ vertex to IP for $\Delta z$ (larger vertex detector volume helps)
- Stat. error dominant

![Graph showing the relationship between the radius of the vertex detector and the statistical error](image)
Charged Higgs

- Needed in many BSM
- Appears in a tree diagrams:
  \[ B^+ \rightarrow \tau^+ \nu, \ B \rightarrow D\tau^+\nu, \ B^+ \rightarrow \mu^+\nu \]
  (also in loops: \( b \rightarrow s\gamma \))
- Universality tests: \( \tau \leftrightarrow \mu, \ c\tau\nu \leftrightarrow u\tau\nu \)

- More than one neutrino, full reconstruction of other \( B \)
- Hermeticity
- Small calorimeter noise hits, good neutral \( E \) resolution

![Diagram showing the charged Higgs and its interactions](image-url)
$B^+ \rightarrow \tau^+ \nu$ at 50 ab$^{-1}$

Excluded region

or, Discovery region
(outside the current excluded region)

- Similar limit from $B \rightarrow D^{(*)} \tau^+ \nu$
- Searches up to $m_{H^+} \sim$ several 100 GeV for large $\tan \beta$
$B \rightarrow D\tau^+\nu$ at 5 and 50 ab$^{-1}$
Lepton flavor violation (LFV)

- Quark mixing $\rightarrow$ KM
- Neutrino mixing $\rightarrow$ MNS
- Charged lepton $\rightarrow$ LFV?
  - LFV through neutrino mixing is extremely small: e.g. $\mathcal{B}(\tau \rightarrow \mu \gamma) \sim 10^{-54}$
  - BSM scenarios (SUSY, etc) generates LFV: SUSY SO(10) $\sim 10^{-8}$, sSUGRA + seesaw $\sim 10^{-7}$

Many modes to search (those including lepton number violation with and without $B - L$)

Searches down to $O(\sim 10^{-9})$
Belle has established the needed decays/techniques

- Decay modes: $b \to s \ell^+ \ell^-, b \to d \gamma, B^+ \to \tau^+ \nu, B \to D^{*} \tau^+ \nu$
- Phases: time-dependent CPV in $b \to s, b \to s \gamma$
\[ \sin(2\beta_{\text{eff}}) = \sin(2\phi_1^{\text{eff}}) \]

### \( b \to cc \) CPV: now

#### World Average
- \( \phi K^0 \):
  - BaBar: 0.68 ± 0.03
  - Belle: 0.50 ± 0.21 ± 0.06
  - Average: 0.40 ± 0.23 ± 0.03
- \( \eta K^0 \):
  - BaBar: 0.71 ± 0.24 ± 0.04
  - Belle: 0.30 ± 0.32 ± 0.08
  - Average: 0.58 ± 0.20
- \( \pi K^0 \):
  - BaBar: 0.61 ± 0.09 ± 0.08
  - Belle: 0.48 ± 0.24
  - Average: 0.61 ± 0.09 ± 0.08
- \( \omega K^0 \):
  - BaBar: 0.48 ± 0.24
  - Belle: 0.33 ± 0.35 ± 0.08
  - Average: 0.38 ± 0.19
- \( f_0 K^0 \):
  - BaBar: 0.90 ± 0.07
  - Belle: 0.18 ± 0.23 ± 0.11
  - Average: 0.85 ± 0.07
- \( \rho_0 K^0 \):
  - BaBar: -0.72 ± 0.71 ± 0.08
  - Belle: -0.43 ± 0.49 ± 0.09
  - Average: -0.52 ± 0.41

#### \( \Delta S \) in QCDF

**Three golden modes**

\[ \delta S_{\text{theo}} \sim 0.02 \]

Definitely need more data to pin down the difference mode by mode.
For 3 ab$^{-1}$

<table>
<thead>
<tr>
<th>N(event)</th>
<th>$\sigma_{\text{stat}}(S)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\phi K^0_S$</td>
<td>1860</td>
</tr>
<tr>
<td>$\phi K^0_L$</td>
<td>720</td>
</tr>
<tr>
<td>$\phi K^0$</td>
<td>2580</td>
</tr>
<tr>
<td>$\eta' K^0_S$</td>
<td>8640</td>
</tr>
<tr>
<td>$\eta' K^0_L$</td>
<td>2760</td>
</tr>
<tr>
<td>$\eta' K^0$</td>
<td>11400</td>
</tr>
<tr>
<td>$K^0_S K^0_S K^0_S$</td>
<td>1140</td>
</tr>
</tbody>
</table>

$\Delta S > 3\sigma$ already with 3 ab$^{-1}$ for the current $S_{\phi K^0} = 0.39$

MC 5 ab$^{-1}$ for $S_{\phi K^0_S} = 0.39$, $A_{\phi K^0_S} = 0$
Prospects on full reconstruction

- Latest Belle code
  - Modes: $D^{(*)}(\pi^+, \rho^+, a_1^+, D_s^{(*)+})$
  - Efficiency: 0.09% for $B^0$, 0.15% for $B^+$

- Problems
  - Not an ultimate approach
    ($\chi^2$ based best-candidate selection)
  - Slow $\pi^\pm$ recovery with SVD tracker

- At upgraded KEKB
  - Beam background: worries in soft photon, $\pi^0$, $\pi^\pm$
  - Soft photon reconstruction:
    — Less material in front of CsI
    — More beam background pile-up

Full reconstruction code is now being revisited
$B \to X_{d\gamma}$ at 5 ab$^{-1}$

- Efficiency 2.9%
- A fit result:
  \[ Y = 4249 \pm 224 \pm 888 \]
- $b \to s\gamma$ component
  \[ \pm 20\% \text{ uncertainty} \]
- Error sources:
  Stat.: 5%
  Fit.: 21%
  Model: 10% (not in $Y$)
  Total: 24%

$B \to X_{d\gamma}$ seems to be possible with 5 ab$^{-1}$! 
(still challenging, systematic error could be quite different in reality)
$A_{FB}(B \rightarrow K^* \ell^+ \ell^-)$ at 5 ab$^{-1}$

- Sensitive to $C_9$ and $C_{10}$ Wilson coefficients
- Full $(q^2, \theta)$ fit with SM $q^2$ dist with leading coefficients only ($A_9$ and $A_{10}$)
- $\delta A_9/A_9 \sim 11\%$
- $\delta A_{10}/A_{10} \sim 13\%$

(i.e., $\delta A_9/A_9 \sim \delta A_{10}/A_{10} \sim 4\%$ at 50 ab$^{-1}$)
Beam-background

- **Vertex (SVD)**
  - Fast readout chip (APV25)
  - Eventually monolithic pixel

- **Drift chamber (CDC)**
  - Larger SVD radius
  - Small cell to shorten drift time

- **Calorimeter (ECL)**
  - Sampling readout + waveform analysis
  - Pure CsI (endcap only, costly...)

- **Muon, $K^0_L$ (KLM)**
  - RPC to scintillator tile

*All these efforts just to compensate*
TOP — Time of projection counter

Cherenkov angle \rightarrow time difference

- Compact, no need of 2-d readout
- Time-resolution $\sim 40$ ps for $>4\sigma K/\pi$ separation
- Best candidate for SuperBelle Barrel PID
Very similar to that of the 5 layer BaBar SVT, supplemented by a new layer 0 to measure the first hit (Goal is coverage to 300 mrad both forward and backward).

- BaBar SVT cannot be re-used because of radiation damage and modest changes in geometry.
- Beam pipe radius and thickness are crucial to obtain adequate resolution in vertex separation.
Sensitivity Comparison ~2020
Super-LHCb 100 fb⁻¹ vs Super-B factory 50 ab⁻¹

SuperB numbers from
M Hazumi - Flavour in
LHC era workshop; LHCb
numbers from Muheim

• This plot is made
by our LHCb friend.
LHCb: 10/fb
Super-LHCb: 100/fb

• LHCb
• Super B

Quite complementary
to each other!