The Belle Experiment

– Current Status & Near Future –

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Contents

1. Introduction to the B physics world
2. $\sin 2\phi_1$ measurement with Belle
3. Upgrade plan of SVD

Ultimate Purpose

- According to the "Big-Bang" theory,
  amount of matter $=$ amount of antimatter $(t = 0)$
- matter-antimatter pair annihilation
- However, our universe is matter dominant

$\Longrightarrow$ A. D. Sakharov's 3 conditions (1967) :

- C and CP violation
- Baryon number non-conservation
- non-equilibrium

Kobayashi-Maskawa model

- Quark mass eigenstate $\neq$ weak eigenstate
- Weak eigenstate : mixture of mass eigenstates

$$\begin{pmatrix} d' \\ s' \\ b' \end{pmatrix} = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} \begin{pmatrix} d \\ s \\ b \end{pmatrix}, \quad V^\dagger V = 1$$

- Coupling between (u, c, t) and (d, s, b) :
  - 2 generations (Cabibbo, 1963) : 2D rotation

$$\begin{pmatrix} \cos\theta_C & \sin\theta_C \\ -\sin\theta_C & \cos\theta_C \end{pmatrix}$$

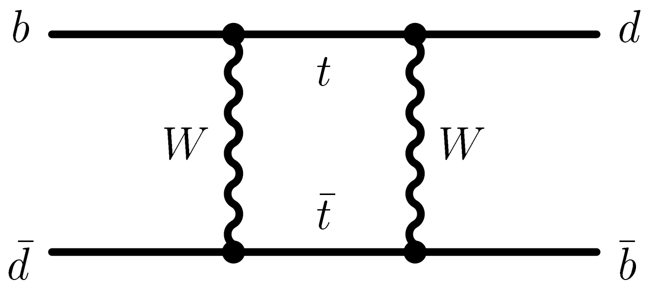
  - 3 generations (Kobayashi and Maskawa, 1973) :

$$\begin{pmatrix} c_1 & -s_1 c_3 & -s_1 s_3 \\ s_1 c_2 & c_1 c_2 c_3 - s_2 s_3 e^{i\delta} & c_1 c_2 s_3 + s_2 c_3 e^{i\delta} \\ s_1 s_2 & c_1 s_2 c_3 + c_2 s_3 e^{i\delta} & c_1 s_2 s_3 - c_2 c_3 e^{i\delta} \end{pmatrix}$$

1 imaginary phase $(\delta) \Rightarrow CP$ violation

CP violation in B^0 meson system

- CP violation has been observed in the K^0 meson system
- Larger CP violation is expected in the B^0 meson system
- B^0-$\bar{B}^0$ mixing was observed in 1987 by ARGUS

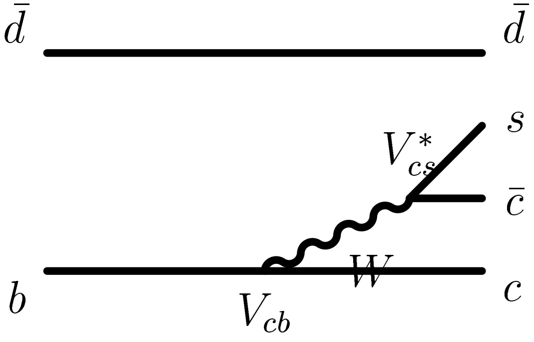


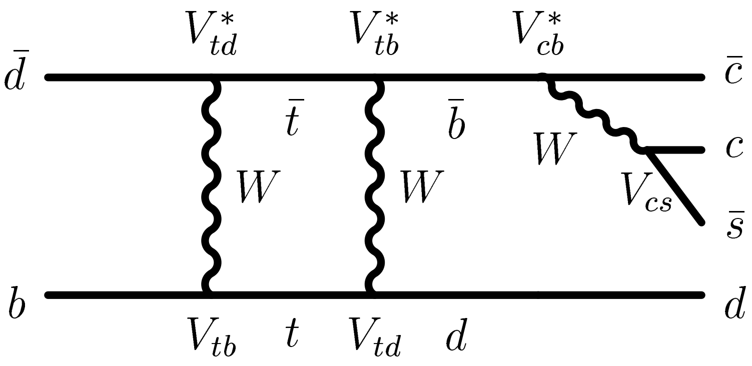
- Mixing gives another path to the final state; $B^0 \to f_{CP}$, $B^0 \to \bar{B}^0 \to f_{CP}$
  $\to CP$ violation

$B \to (c\bar{c})K^0$ and $\sin 2\phi_1$

- The time-dependent rates for B^0 and $\bar{B}^0$ decays to $f_{CP} = (c\bar{c})K^0$

$$A(t) = \frac{\Gamma(\bar{B}^0 \to f_{CP}) - \Gamma(B^0 \to f_{CP})}{\Gamma(\bar{B}^0 \to f_{CP}) + \Gamma(B^0 \to f_{CP})} = -\xi_f \sin 2\phi_1 \sin \Delta m_d t$$



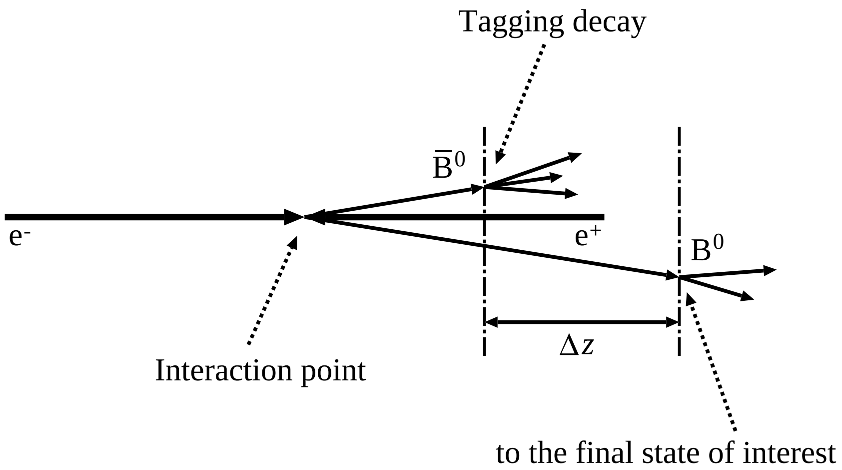


- the proper time distribution

$$\mathcal{P} = \frac{e^{-|\Delta t|/\tau}}{2\tau} \{1 - \xi_f q(1 - 2\omega_l) \sin 2\phi_1 \sin(\Delta m_d \Delta t))\}$$

Asymmetric B-Factories

- Proper Time measurement $\rightarrow$ Flight Length measurement



- $e^+ e^- \rightarrow \Upsilon(4S) \rightarrow B\bar{B}$ w/ $E^+ \neq E^-$

Accelerator	Detector	Institute	E^- (GeV)	E^+ (GeV)	$\beta\gamma$	$\mathcal{L}(cm^{-2}s^{-1})$	$\int \mathcal{L}dt$
PEP-II	BaBar	SLAC	9.0	3.1	.56	33×10^{32}	$38\,\mathrm{fb}^{-1}$
KEKB	Belle	KEK	8.0	3.5	.43	45×10^{32}	$33\,\mathrm{fb}^{-1}$

World blightest $e^+ e^-$ collider!!!