AIS

CP Violation Present Status and Future Prospcts

A. I. Sanda
Nagoya University

Why B ?

History

- Discovery of K meson 1947
- Discovery of CP violation 1964
- Discovery of Υ(4S) 1980
- Discovery of CP violation in B decays 2000

B is 34 years behind K

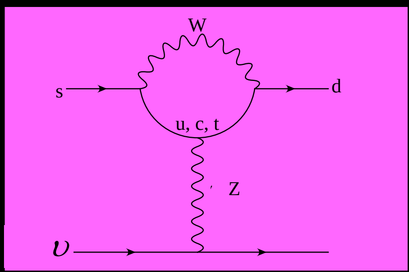
K physics has been going on for 53 years

B physics will go on for another 50 years

Rare B Decays

Reveals more new physics than

Rare K decays



When I was 27, I was excited by $K \to \pi e^+ e^-$ as this was a loop effect which will be a critical test of gauge theory!

$$\frac{Br(B \to X_s \nu \bar{\nu})}{Br(B \to X_c e \bar{\nu})} = \frac{3\alpha^2}{4\pi^2 \sin^4\theta_W} \left| \frac{V_{tb} V_{ts}^*}{V_{cs}} \right|^2 \frac{X^2(x_t)}{f(z)}$$

$$\frac{Br(K \to X_s \nu \bar{\nu})}{Br(K \to X_c e \bar{\nu})} = \frac{3\alpha^2}{4\pi^2 \sin^4\theta_W} \left| \frac{V_{td} V_{ts}^*}{V_{us}} \right|^2 \frac{X^2(x_t)}{f(z)}$$

$$\frac{V_{ts}}{V_{cs}} \approx O\left(\lambda^2\right) \qquad \frac{V_{td} V_{ts}^*}{V_{us}} \approx O\left(\lambda^4\right)$$

$$Br(K_L \to \pi^0 \nu \bar{\nu}) = 4.1 \times 10^{-10} A^4 \eta^2$$

$$Br(K_L \to \mu^+ \mu^-) = 1.7 \times 10^{-9} A^4 (\rho_0 - \rho)^2$$

$$Br(B^+ \to X_s^+ \nu \bar{\nu}) = 4.1 \times 10^{-5}$$

B's show the loop effects better than K's

$K - \bar{K}$ Mixing

$$K \to \pi^+\pi^-$$

$$\bar{K} \to \pi^+\pi^-$$

$$K \to \pi^+\pi^- \to \bar{K}$$

$$|K(t)\rangle = a(t)|K\rangle + b(t)|\bar{K}\rangle + c(t)|\pi^+\pi^-\rangle$$
$$+\mathrm{d(t)}|3\pi\rangle + e(t)|\pi l \upsilon\rangle + \cdots$$

$$\frac{d}{dt}|K(t)\rangle = H|K(t)\rangle$$

Wigner-Weisskopf approximation

- c(0), d(0), e(0), •••=0
- t> 強い相互作用の時間スケール
- a(t), b(t) 以外興味がない。

$$|\psi(t)>= a(t)|K> + b(t)|\bar{K}>$$

$$i\hbar\frac{d}{dt}\begin{pmatrix} a(t) \\ b(t) \end{pmatrix} = H\begin{pmatrix} a(t) \\ b(t) \end{pmatrix}$$

$$H = M - \frac{i}{2}\Gamma = \begin{pmatrix} M_{11} - \frac{i}{2}\Gamma_{11} & M_{12} - \frac{i}{2}\Gamma_{12} \\ M_{12}{}^* - \frac{i}{2}\Gamma_{12}{}^* & M_{22} - \frac{i}{2}\Gamma_{22} \end{pmatrix}$$

$$M_{12} = \sum_n P\left[\frac{\langle K|H_W|n\rangle\langle n|H_W|\bar{K}\rangle}{m_K{}^2 - m_n{}^2}\right]$$

$$\Gamma_{12} = 2\pi\sum_F \delta(m_K - m_F)\langle K|H_W|F\rangle\langle F|H_W|\bar{K}\rangle$$

$$K \to F$$

$$\bar{K} \to F$$

CPT symmetry $M_{11} - \frac{i}{2}\Gamma_{11} = M_{22} - \frac{i}{2}\Gamma_{22}$

CP symmetry $M_{12} - \frac{i}{2}\Gamma_{12} = M_{21} - \frac{i}{2}\Gamma_{21}$

Since M and Γ are hermitian,

$$M_{21} = M_{21}^* \qquad \Gamma_{21} = \Gamma_{21}^*$$

Complex M_{12} or Γ_{12} violate CP symmetry

Mass Mixing

$$a|K\rangle + b|\bar{K}\rangle = \begin{pmatrix} a \\ b \end{pmatrix}$$

$$i\frac{d}{dt}\begin{pmatrix} a \\ b \end{pmatrix} = H\begin{pmatrix} a \\ b \end{pmatrix}$$

$$\begin{pmatrix} M_{11} - \frac{i}{2}\Gamma_{11} & M_{12} - \frac{i}{2}\Gamma_{12} \\ M_{21} - \frac{i}{2}\Gamma_{21} & M_{22} - \frac{i}{2}\Gamma_{22} \end{pmatrix} = (M_{11} - \frac{i}{2}\Gamma_{11})\begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix} + (M_{21} - \frac{i}{2}\Gamma_{21})\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

$$\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}\begin{pmatrix} 1 \\ \pm 1 \end{pmatrix} = \pm\begin{pmatrix} 1 \\ \pm 1 \end{pmatrix} \qquad |K_\pm\rangle = \frac{1}{\sqrt{2}}\left[|K\rangle \pm |\bar{K}\rangle\right]$$

CP eigenstate

K_{LONG}とK_{SHORT}

C	π^{+} —— π^{-}	=	π^{-} —— π^{+}
P	π^{-} —— π^{+}	=	π^{+} —— π^{-}

$$CP\left|\pi^{+}\pi^{-}\right\rangle = +\left|\pi^{+}\pi^{-}\right\rangle$$

$$CP\,|K> = |\overline{K}>$$

$$|K_1> = \frac{1}{\sqrt{2}}\left[|K> + |\overline{K}>\right]$$

$$|K_2> = \frac{1}{\sqrt{2}}\left[|K> - |\overline{K}>\right]$$

$$CP\,|K_1> = |K_1>$$

$$CP\,|K_2> = -|K_2>$$

$$K_1 \rightarrow 2\pi$$

$$K_2 \rightarrow 3\pi$$

$$m_K = 500MeV$$

$$3m_\pi = 420MeV$$

$$K_1 = K_S$$

$$K_2 = K_L$$

Hの固有状態

$$|K_S> = |K_1> = \frac{1}{\sqrt{2}}\left[|K> + |\overline{K}>\right]$$

$$|K_L> = |K_2> = \frac{1}{\sqrt{2}}\left[|K> - |\overline{K}>\right]$$

個有値

$$K_L : m_L - \tfrac{i}{2}\Gamma_L$$

$$K_S : m_S - \tfrac{i}{2}\Gamma_S$$

$$\begin{pmatrix} M_{11}-\frac{i}{2}\Gamma_{11} & M_{12}-\frac{i}{2}\Gamma_{12} \\ M_{21}-\frac{i}{2}\Gamma_{21} & M_{22}-\frac{i}{2}\Gamma_{22} \end{pmatrix}$$

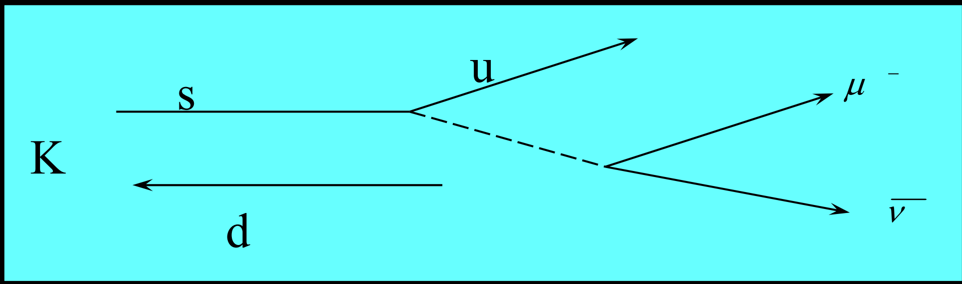
時間依存性

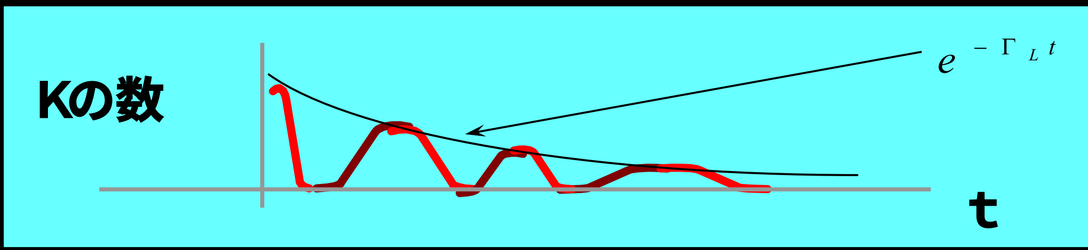
$$|K(t)> = \frac{1}{\sqrt{2}}\left[e^{-im_S t-\Gamma_S t}\,|K_S> + e^{-im_L t-\Gamma_L t}\,|K_L>\right]$$

$$|\overline{K}(t)> = \frac{1}{\sqrt{2}}\left[e^{-im_S t-\Gamma_S t}\,|K_S> - e^{-im_L t-\Gamma_L t}\,|K_L>\right]$$

$$|K(t)> = \tfrac{1}{2}\left[e^{-im_S t-\Gamma_S t}(|K> + |\overline{K}>) + e^{-im_L t-\Gamma_L t}(|K> - |\overline{K}>)\right]$$

$$|K(t)> = \tfrac{1}{2}\left[(e^{-im_S t-\Gamma_S t} + e^{-im_L t-\Gamma_L t})|K> + (e^{-im_S t-\Gamma_S t} + e^{-im_L t-\Gamma_L t})|\overline{K}>\right]$$

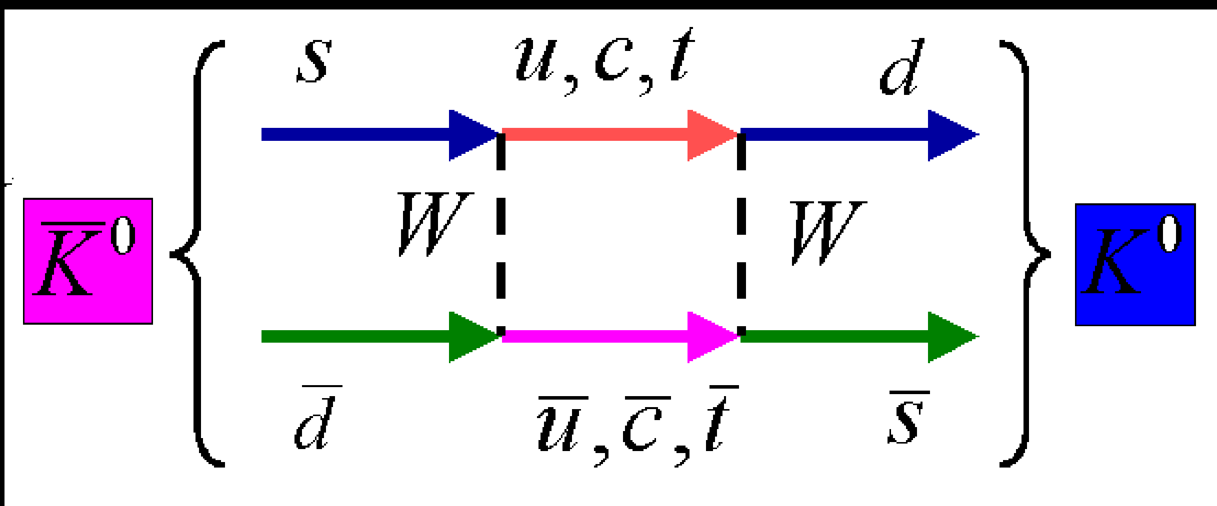




$$\frac{1}{4}\left(e^{-\Gamma_L t} + e^{-\Gamma_S t} + e^{-\frac{\Gamma_L+\Gamma_S}{2}t}\cos(\Delta m t)\right)$$

K中間子ー反K中間子遷移

CP 非保存

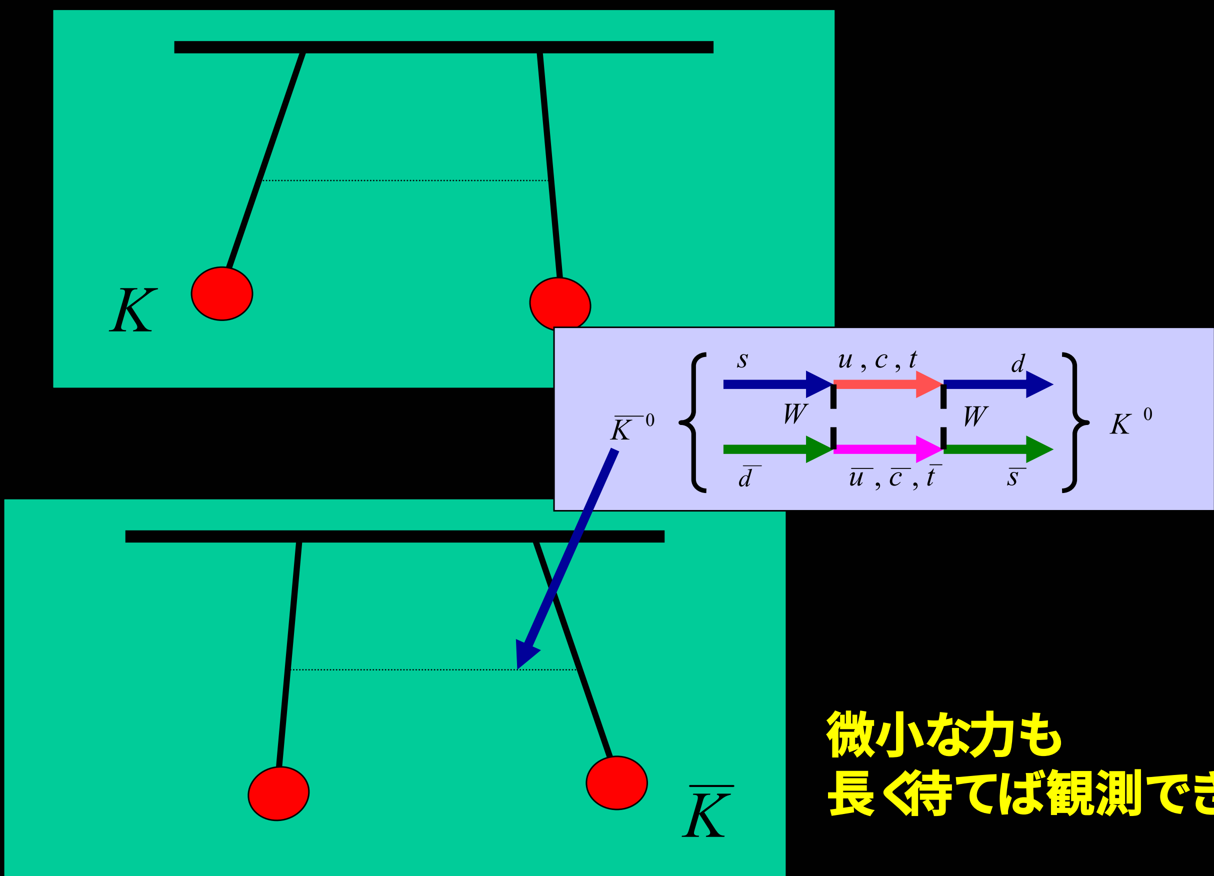


この遷移がおこるのはK－反Kだけ

K中間子系でのCP非保存はどう理解するのか

三田一郎　名古屋大学大学院　理学研究科

振り子は敏感な顕微鏡



微小な力も
長く待てば観測できる

三田一郎　名古屋大学大学院　理学研究科

CP symmetry and complex phase

$$H = ch + c^* h^\dagger$$

h particle dynamics

$h^\dagger$ anti-particle dynamics

$$CP\ h\ CP^\dagger = h^\dagger$$

$$CPHCP^\dagger = ch^\dagger + c^* h$$

If c is complex, worlds is not invariant under CP

$$|\psi(t)>= a(t)|K> + b(t)|\bar{K}>$$

$$i\hbar \frac{d}{dt}\begin{pmatrix} a(t) \\ b(t) \end{pmatrix} = H \begin{pmatrix} a(t) \\ b(t) \end{pmatrix}$$

$$H = M - \frac{i}{2}\Gamma = \begin{pmatrix} M_{11} - \frac{i}{2}\Gamma_{11} & M_{12} - \frac{i}{2}\Gamma_{12} \\ M_{12}^* - \frac{i}{2}\Gamma_{12}^* & M_{22} - \frac{i}{2}\Gamma_{22} \end{pmatrix}$$

$$M_{12} \neq M_{12}^*$$

$$\Gamma_{12} \neq \Gamma_{12}^*$$

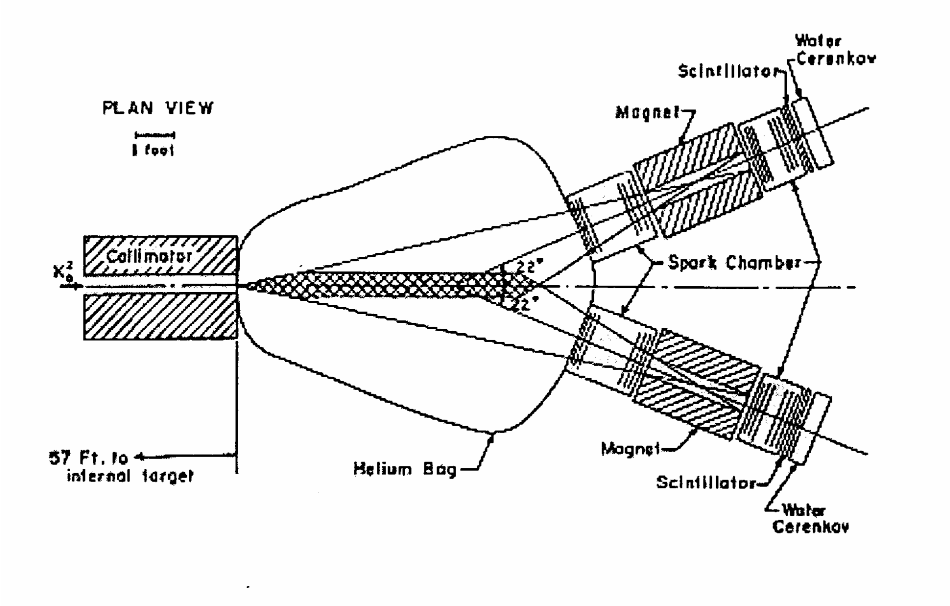
$$|K_S>=|K_1> + \varepsilon|K_2>$$

$$|K_L>=|K_2> + \varepsilon|K_1>$$

$$K_L \to \pi\pi$$

Discovery of CP violation

Fitch-Cronin experiment



$$\frac{\Gamma(K_L \to \pi^+\pi^-)}{\Gamma(K_S \to \pi^+\pi^-)} = (2\times 10^{-3})^2$$

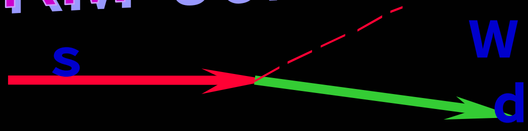
The Standard Model

$$H_W = \begin{pmatrix} \bar{u} \\ \bar{c} \\ \bar{t} \end{pmatrix}^T ig\gamma^\mu \begin{pmatrix} d \\ s \\ b \end{pmatrix} W_\mu^+ \ + \ \mathrm{h.c.}$$

$$H_H = \begin{pmatrix} \bar{u} \\ \bar{c} \\ \bar{t} \end{pmatrix}^T \begin{pmatrix} Y_{uu} & Y_{cu} & Y_{tu} \\ Y_{cu} & Y_{cc} & Y_{ct} \\ Y_{tu} & Y_{tc} & Y_{tt} \end{pmatrix} \begin{pmatrix} u \\ c \\ t \end{pmatrix} \varphi^0$$

$$H_W = \begin{pmatrix} \bar{u}_m \\ \bar{c}_m \\ \bar{t}_m \end{pmatrix}^T ig\gamma^\mu V_{KM} \begin{pmatrix} d_m \\ s_m \\ b_m \end{pmatrix} W_\mu^+ \ + \ \mathrm{h.c.}$$

KM scheme of CPV



Phases of the KM matrix

3 x3 unitary matrix has 9 real parameters

$$q_i \rightarrow e^{i\phi_i} q_i$$

For 6 quarks, there are 5 phases we can adjust

KM matrix has 4 parameters

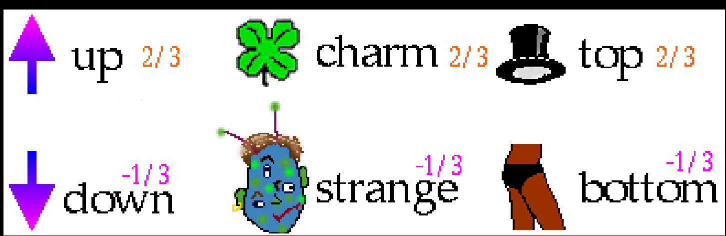
3 rotation angle

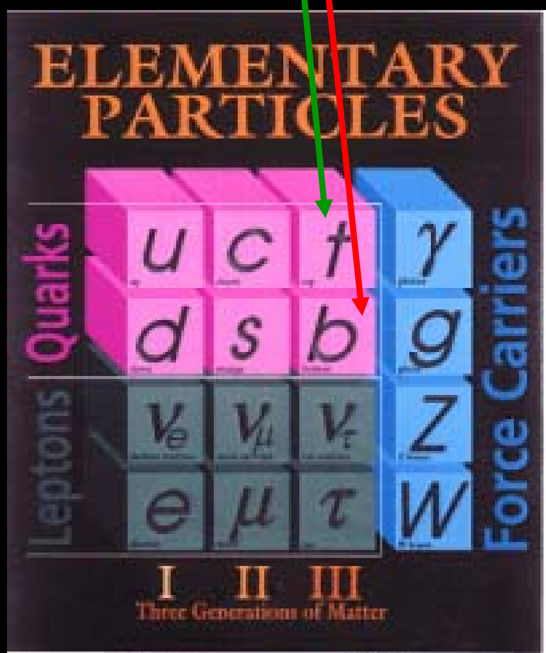
1 CPV phase

より深くCPを理解するために

当時未発見

素粒子の種類





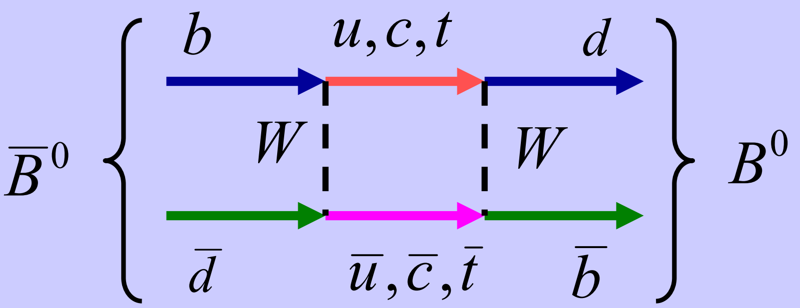
$$K = (s\bar{d})$$

1980年には未発見

$$B = (b\bar{d})$$

1980年の計算

$\overline{B}^0 \longleftrightarrow B^0$ の遷移

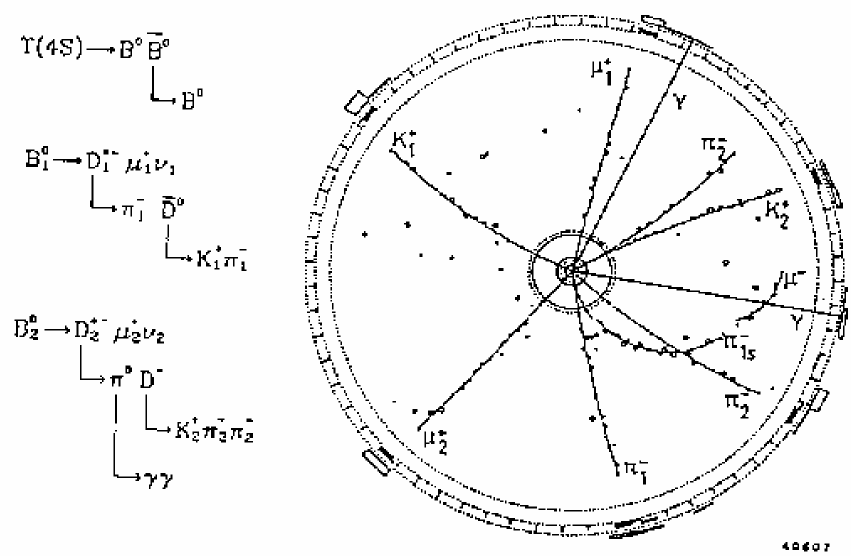


s を b に変えるだけ？

In 1979 we did not know V_{ij}, M_t

Discovery of B–$\overline{\text{B}}$ mixing

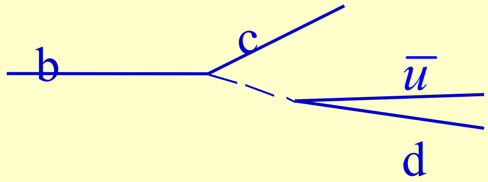
$B \Rightarrow \pi\pi \Rightarrow \overline{B}$

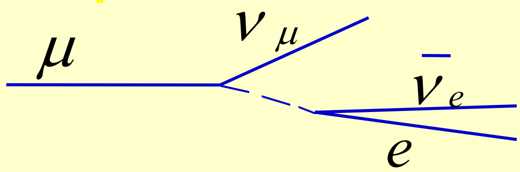


ARGUS 87

Longevity of B mesons

Extremely long Life time - 1ps





$$\Gamma = \frac{G_F^2 M_b^5}{192\pi^3}(6+3)|V_{cb}|^2 \qquad \Gamma = \frac{G_F^2 M_\mu^5}{192\pi^3}$$

$V_{cb} \approx 1,\ \tau_B \approx 10^{-15}$ sec

Needs time to show interesting physics

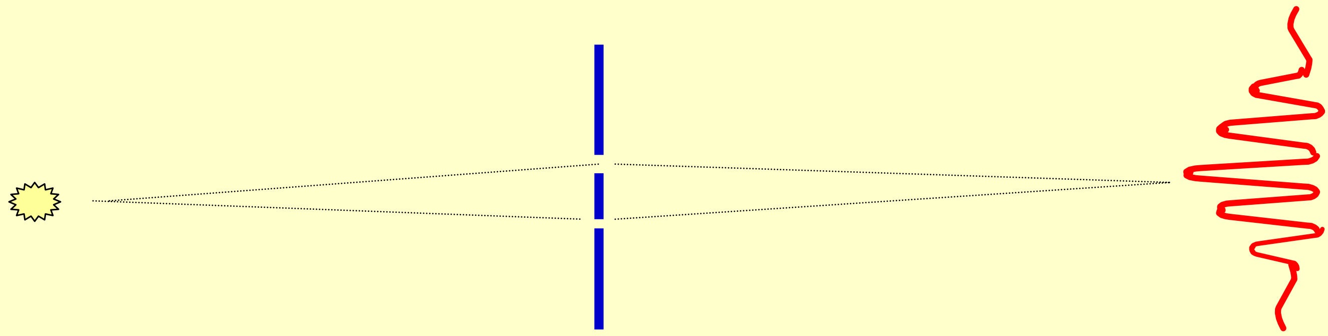
$$\frac{1}{4}\left(e^{-\Gamma_L t} + e^{-\Gamma_S t} + e^{-\frac{\Gamma_L + \Gamma_S}{2}t}\cos(\Delta m t)\right)$$

$$\Delta mt = \frac{\Delta m}{\Gamma}\frac{t}{\tau} \qquad \frac{\Delta m}{\Gamma} = \frac{life \quad time}{mixing \quad time}$$

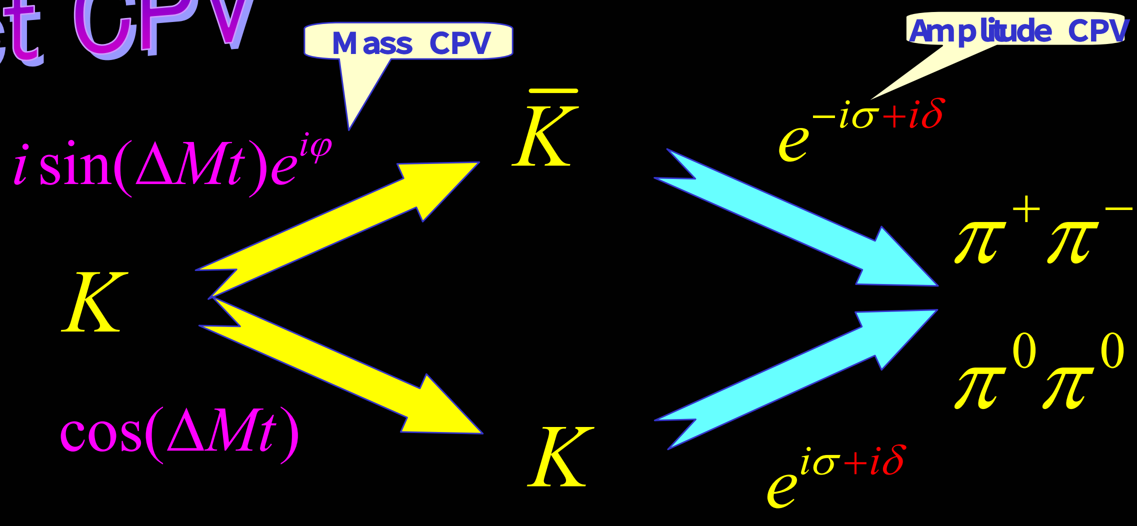
How do we detect CP violation?

Experimentalists can only count the number of particles
They can't use protractor to measure the phase angle!

Measuring an angle by counting particles in optics



Direct CPV

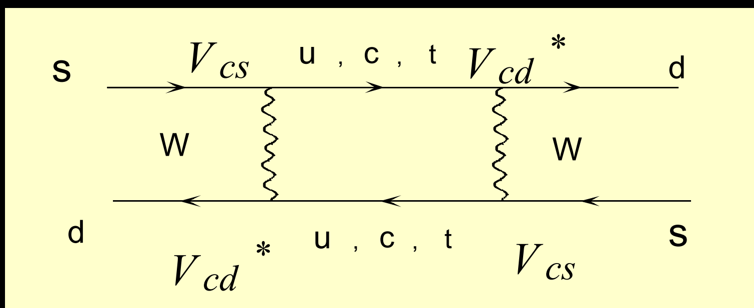


$$\eta_{+-} = \frac{A(K_L \to \pi^+\pi^-)}{A(K_S \to \pi^+\pi^-)} = \varepsilon + \varepsilon'$$

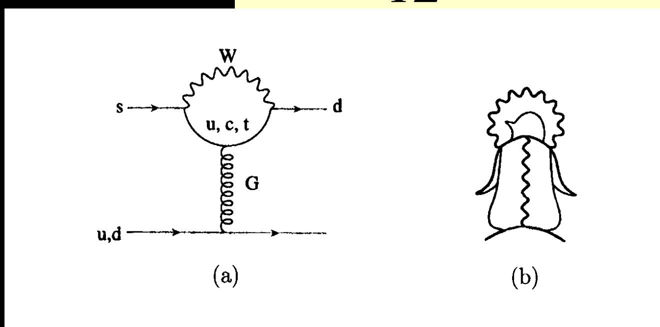
$$\eta_{00} = \frac{A(K_L \to \pi^0\pi^0)}{A(K_S \to \pi^0\pi^0)} = \varepsilon - 2\varepsilon'$$

$\frac{\varepsilon'}{\varepsilon} \neq 0$ — established — NA31(93) E832 (99)

How do phases appear?



M_{12} becomes complex

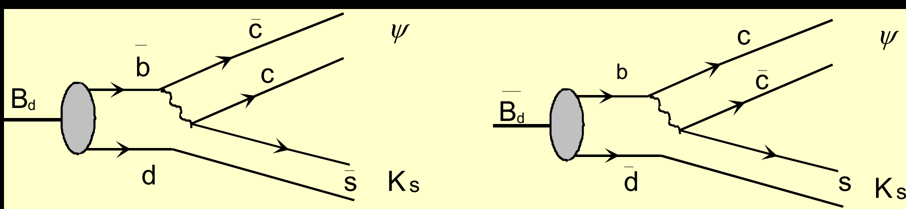


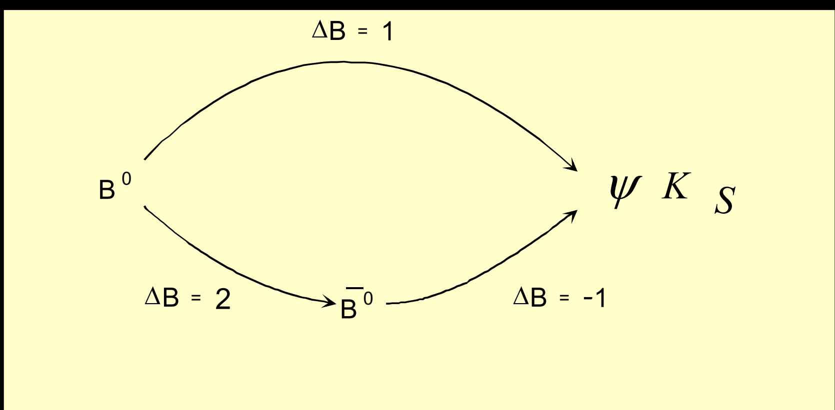
$A(K \to \pi\pi)$ becomes complex

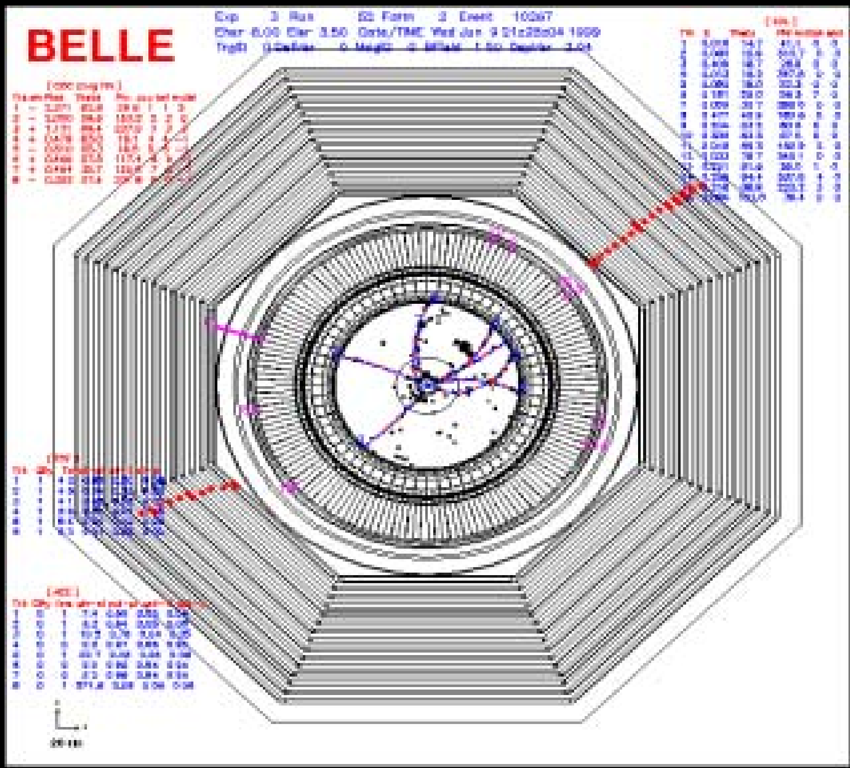
$\frac{\varepsilon'}{\varepsilon} \neq 0$

Penguins and me in Cape Town, Jan., 1999

For B decay, Gold plated decays



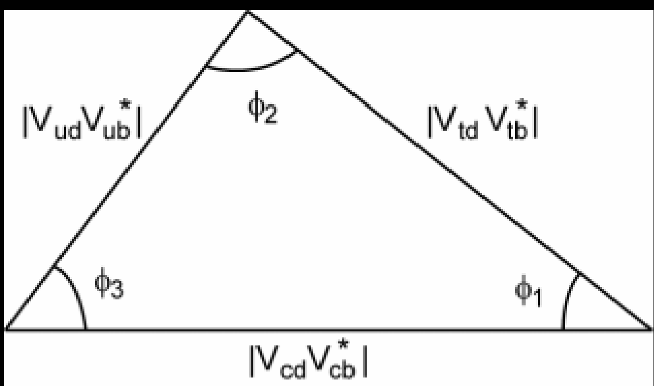




$B \rightarrow \psi K_L$

Unitarity Triangle

$$\begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix}$$



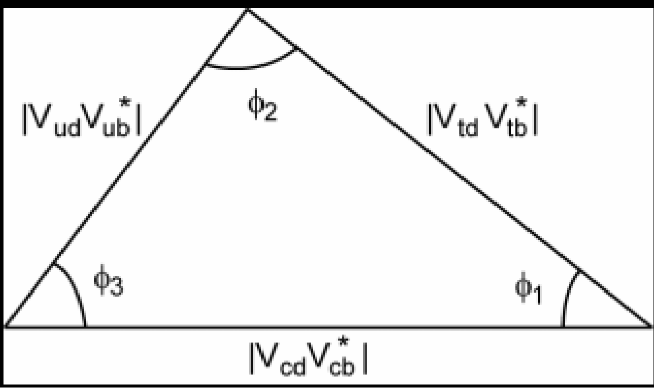
$$V_{ub}^* V_{ud} + V_{cb}^* V_{cd} + V_{tb}^* V_{td} = 0$$

CPV in B decays

$$\frac{\Gamma(B(t)\to\psi K_S)-\Gamma(\overline{B}(t)\to\psi K_S)}{\Gamma(B(t)\to\psi K_S)+\Gamma(\overline{B}(t)\to\psi K_S)}\approx\sin(2\phi_1)\sin\left(\frac{\Delta m}{\Gamma}\frac{t}{\tau}\right)$$

$$\sin(2\phi_1)=\mathrm{Im}\left[\frac{V_{tb}V_{td}^{*}V_{cb}^{*}V_{cd}}{V_{tb}^{*}V_{td}V_{cb}V_{cd}^{*}}\right]$$

$\pi^+\pi^-$



Nearly 100% **CPV**

ψK_S

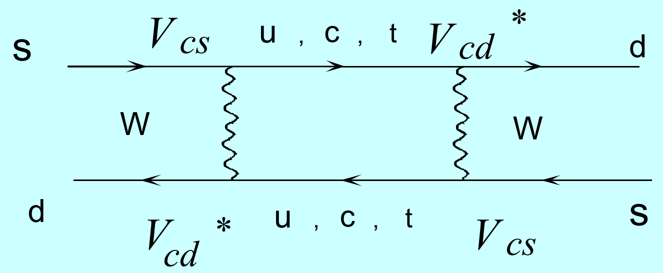
Why CPV in B so large?

Three families needed

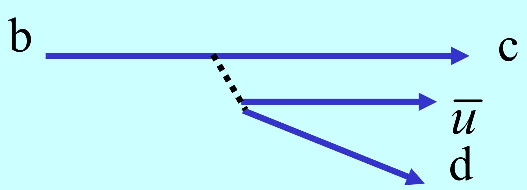
3 x3 unitary matrix has 9 real parameters

$$q_i \to e^{i\phi_i} q_i$$

For 6 quarks, there are 5 phases we can adjust

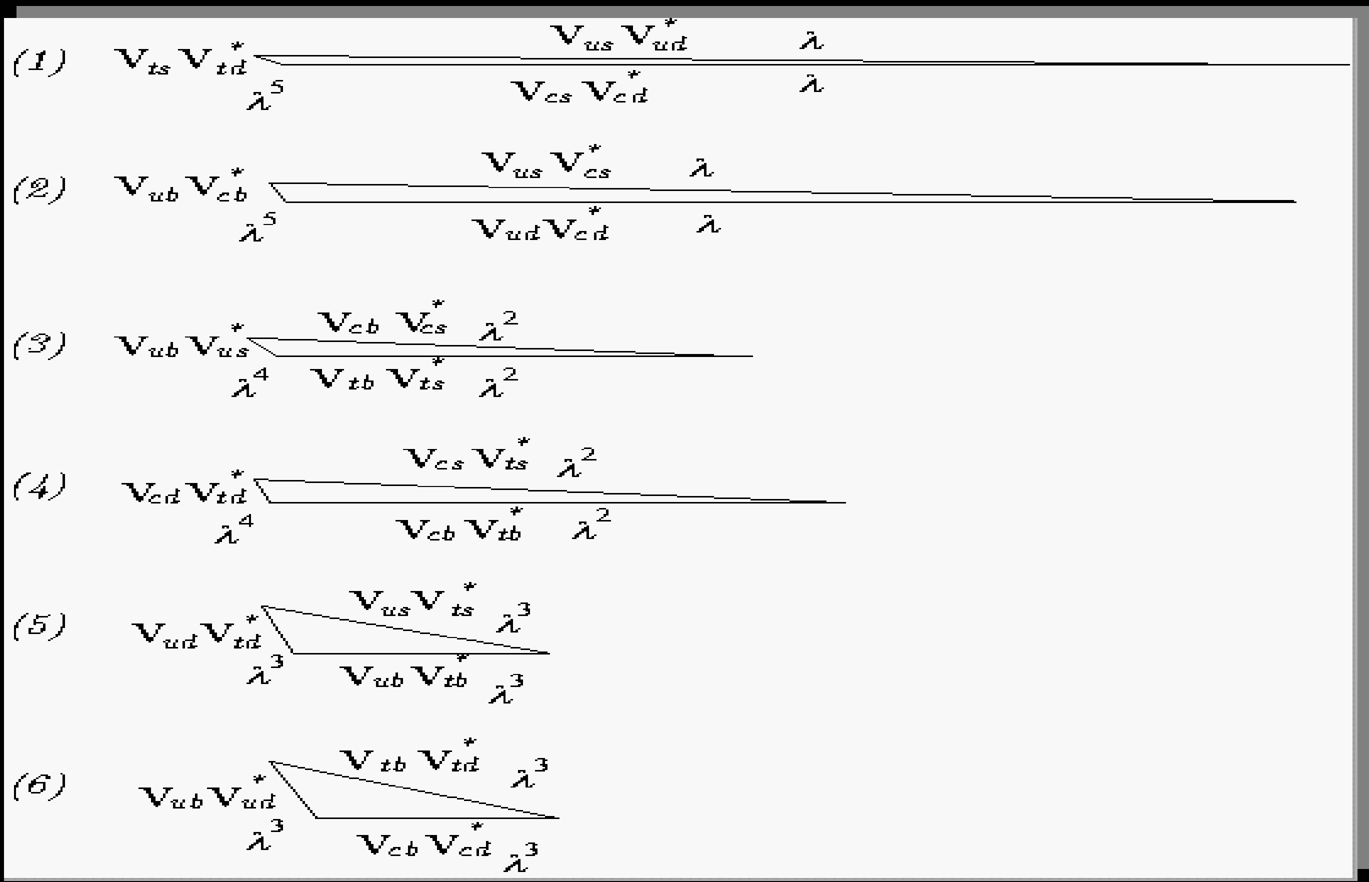


K system



B system

Why is CPV in K decays so small?

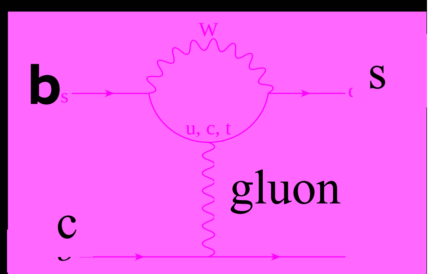


Miracle

$$\frac{\Gamma(B(t)\to\psi K_S)-\Gamma(\overline{B}(t)\to\psi K_S)}{\Gamma(B(t)\to\psi K_S)+\Gamma(\overline{B}(t)\to\psi K_S)}\approx\sin(2\phi_1)\sin\left(\frac{\Delta m}{\Gamma}\frac{t}{\tau}\right)$$

$$\sin(2\phi_1)=\mathrm{Im}\left(\frac{M_{12}^*}{M_{12}}\rho\right)\qquad \rho=\frac{A(\overline{B}\to\psi K_S)}{A(B\to\psi K_S)}$$

$$\rho=\frac{V_{cb}V_{cs}^*T+V_{tb}V_{ts}^*P}{V_{cb}^*V_{cs}T+V_{tb}^*V_{ts}P}$$



$$V_{cb}V_{cs}^*+V_{tb}V_{ts}^*+V_{tb}V_{ts}^*=0$$

$$V_{cb}V_{cs}^*=-V_{tb}V_{ts}^*+O(\lambda^2)$$

No miracle

$$\frac{\Gamma(B(t)\to\pi^+\pi^-)-\Gamma(\bar{B}(t)\to\pi^+\pi^-)}{\Gamma(B(t)\to\pi^+\pi^-)+\Gamma(\bar{B}(t)\to\pi^+\pi^-)}\approx \mathrm{Im}\left(\frac{M_{12}^{\ *}}{M_{12}}\rho\right)$$

$$\rho=\frac{A(\bar{B}\to\pi^+\pi^-)}{A(B\to\pi^+\pi^-)}$$

$$\rho=\frac{V_{cb}V_{cs}^{\ *}T+V_{tb}V_{ts}^{\ *}P}{V_{cb}^{\ *}V_{cs}T+V_{tb}^{\ *}V_{ts}P}$$

Penguins are larger than we thought

If we assume penguins are small

$$\frac{A(B\to K\pi)}{A(B\to\pi\pi)}=\frac{V_{ub}^{\ *}V_{us}T+V_{tb}^{\ *}V_{ts}P}{V_{ub}V_{ud}^{\ *}T+V_{tb}V_{tu}^{\ *}P}$$

$$\frac{A(B\to K\pi)}{A(B\to\pi\pi)}=\frac{\lambda^4+\lambda^2\frac{P}{T}}{\lambda^3+\lambda^3\frac{P}{T}}\sim\lambda$$

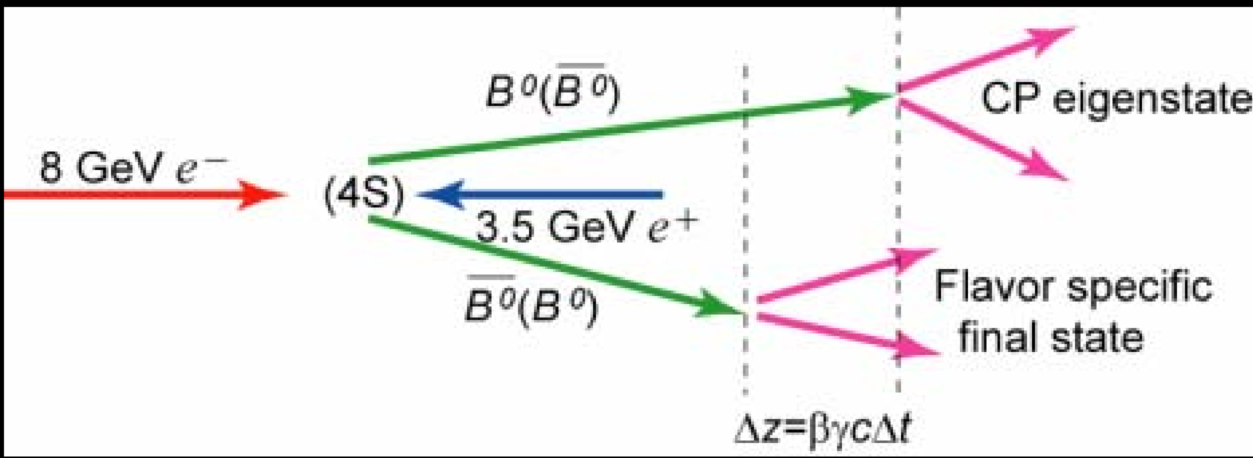
$$\frac{Br(B\to K\pi)}{Br(B\to\pi\pi)}>1$$

Experiment(CLEO)

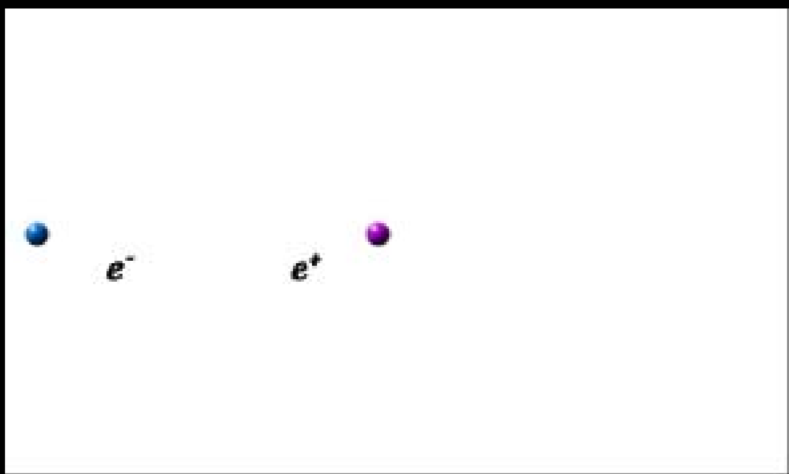
$$\frac{P}{T}\approx\lambda\approx .25$$

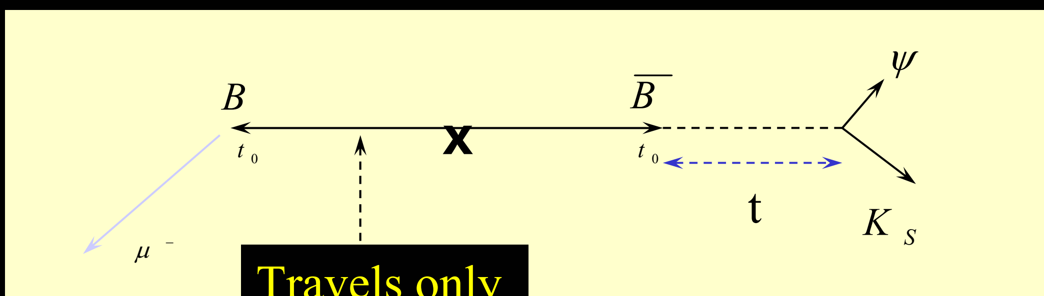
We need penguins
But, they pollute!

Principle of measurement



Why asymmetric collider

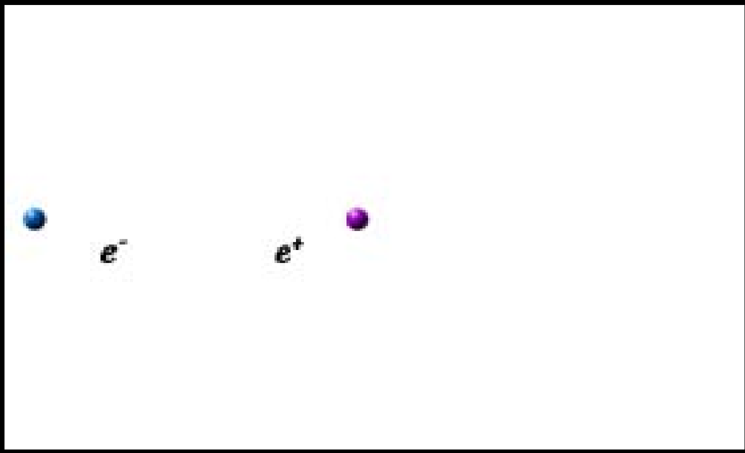


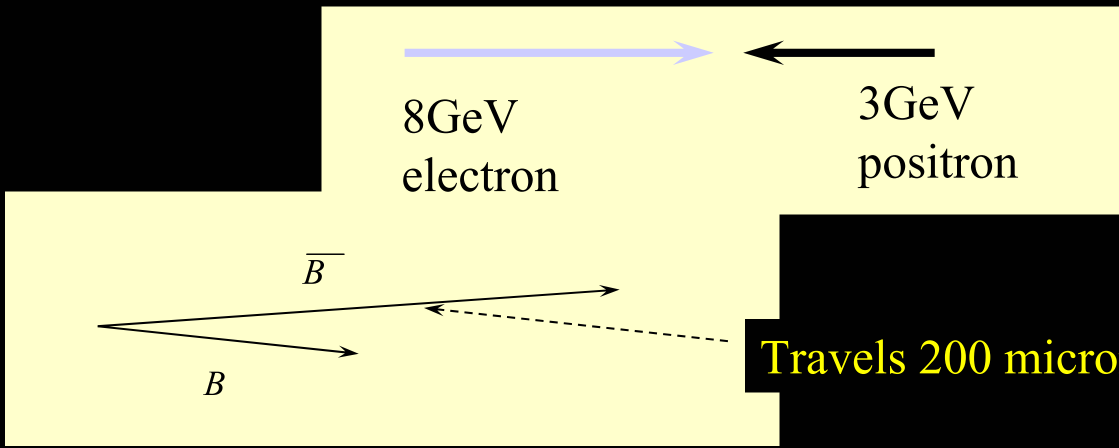


Travels only
20 microns

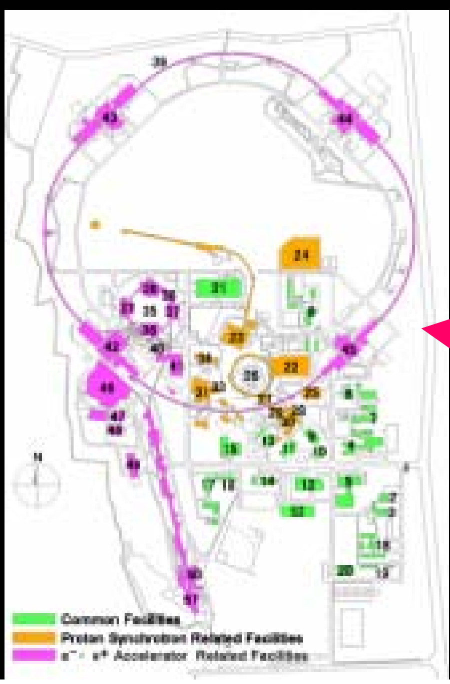
Impossible to measure
With present technology

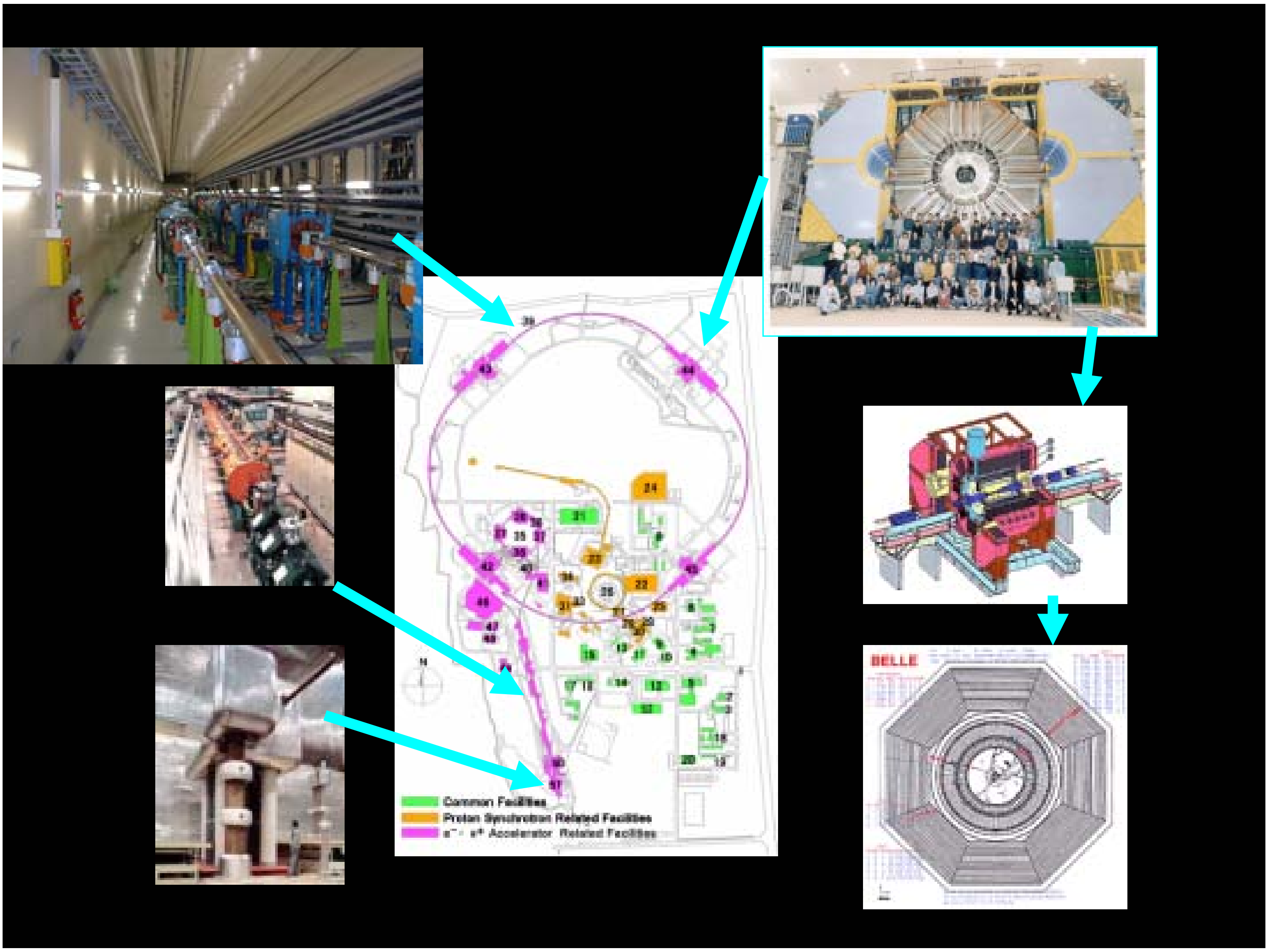
Asymmetric collider

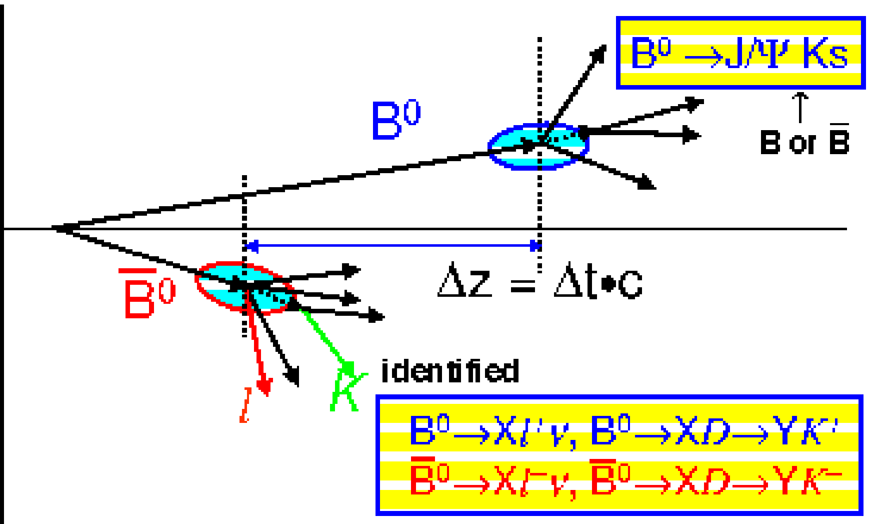


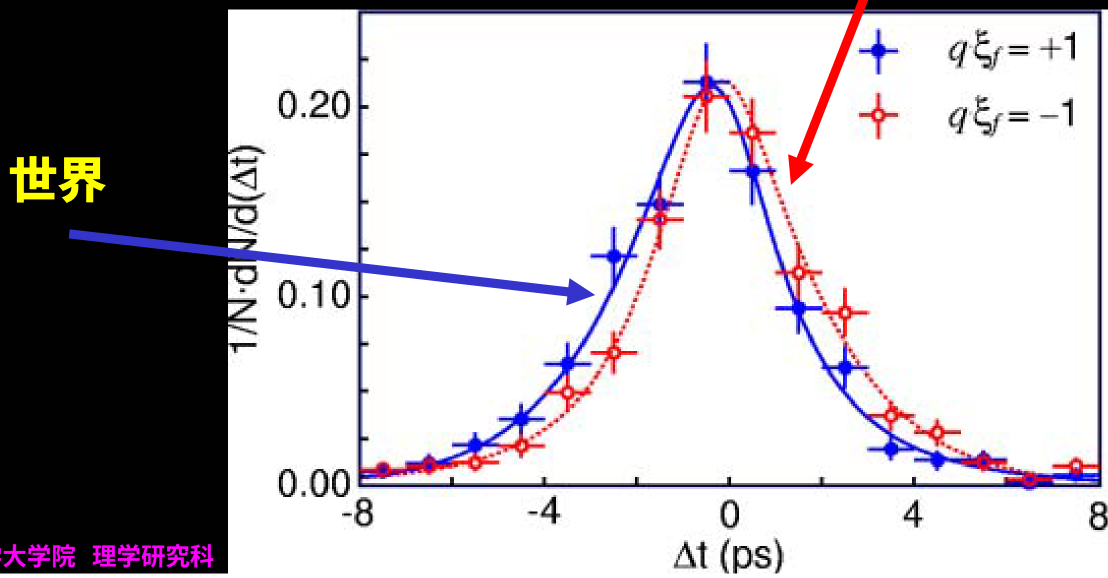


KEK

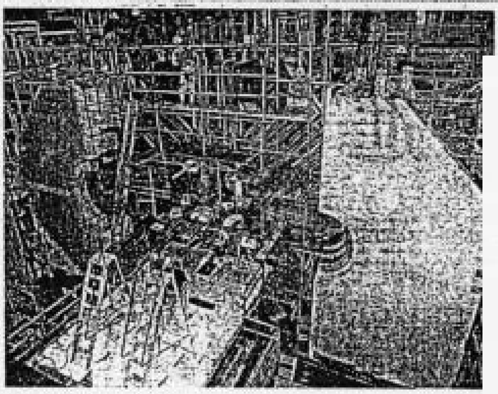



Common Facilities
Proton Synchrotron Related Facilities
e⁻ · e⁺ Accelerator Related Facilities
BELLE


B⁰ →J/Ψ Ks
B or B̄
B⁰
B̄⁰
Δz = Δt•c
identified
l
K
B⁰→Xl⁺ν, B⁰→XD→YK⁺
B̄⁰→Xl⁻ν, B̄⁰→XD→YK⁻


反世界
世界
qξf = +1
qξf = −1
1/N·dN/d(Δt)
0.20
0.10
0.00
-8
-4
0
4
8
Δt (ps)

大きな「対称の破れ」発見



CP対称性の破れを見つけた高エネルギー加速器研究機構の素粒子検出器「BELLE」＝98年12月、つくば市

つくば 高エネ研 素粒子

年発表）に基づき、三田一郎名古屋大教授が八一年に予想した。

今回の結果は、小林・益川理論の基本的な正しさを裏付けたことにもなり、ノーベル賞級といわれる同理論への評価がさらに高まるとみられる。

素粒子の標準理論　素粒子に関する実験や理論体系を総合して1970年代につくられた理論。ニュートリノの質量をゼロとしていたため、3年前、ニュートリノに質量が見つかり若干の拡張が必要になったが、それ以外に修正を迫る実験結果はこれまでなかった。ただ、素粒子の質量の大きさを説明できないといった難点もあり、理論の拡張が提案されている。

400億円

「反粒子」の消滅

宇宙のナゾ解く現象の存在確認

高エネ研、解明へ一歩

日本経済新聞
13年7月24日 夕
12版38面

CP対称性大きな破れ

素粒子実験で発見

標準理論超える？

胸部大動脈瘤の摘出 開胸せず手術

三田一郎　名古屋大学大学院　理学研究科

なぜ21年かかったのか？

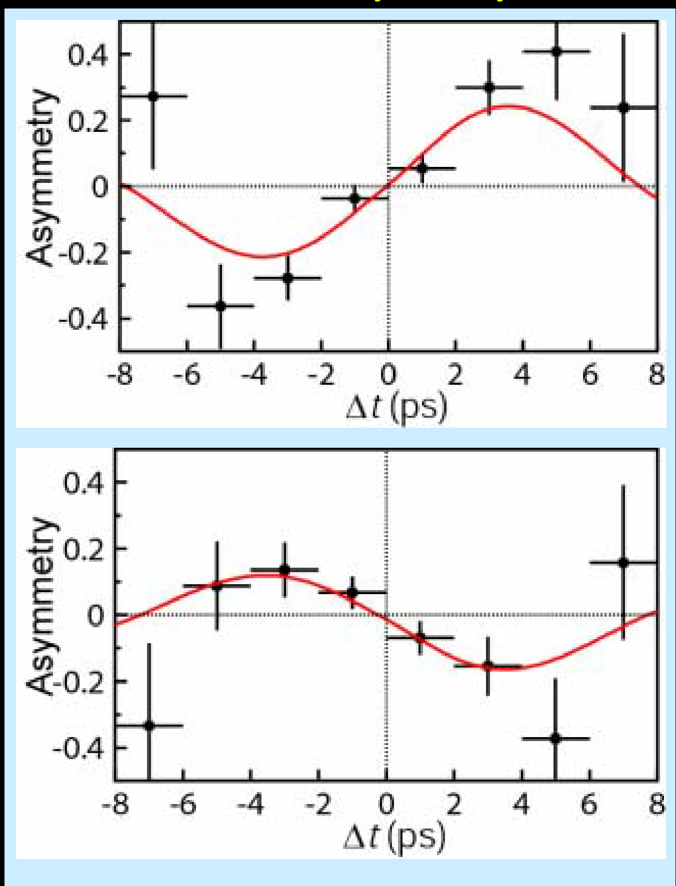
1. 1980年　B崩壊における大きなCPの破れの予言
   B中間子を発見
2. 1983年　B中間子の寿命の測定
3. 1987年　B-反B遷移が発見された
4. 崩壊する前に残す飛跡はわずか　0.02mm
5. 0.01秒にデータを処理する。
   0.02mmの飛跡を追うのは無理
6. 非対称加速器　　飛跡が　0.2mmになる

三田一郎　名古屋大学大学院　理学研究科

Present status

Comparison between CP-odd and -even

Raw asymmetry



$\int L\, dt = 78\ fb^{-1}$

CP = −1 sample

$\sin 2\phi_1$
= 0.716±0.083

CP = +1 sample
($B^0 \rightarrow J/\psi K_L$)

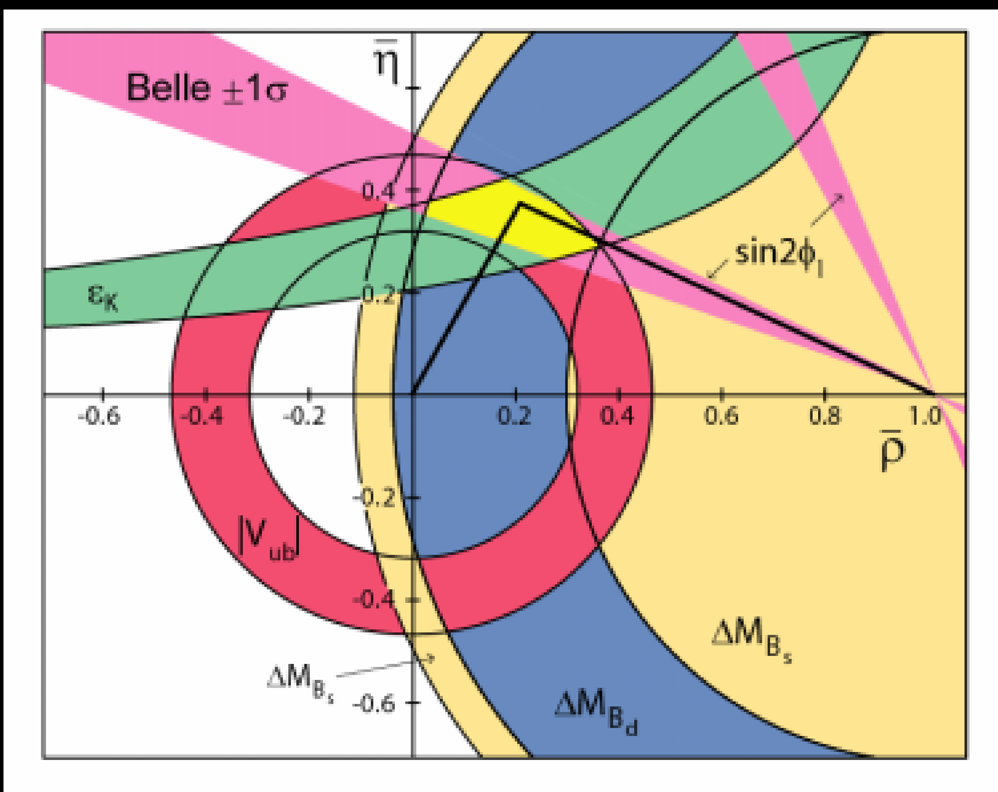
$\sin 2\phi_1$
= 0.78±0.17

Yamauchi KEK

Wolfenstein Parametrization

$$V_{KM} = \begin{pmatrix} 1-\frac{1}{2}\lambda^2 & \lambda & A\lambda^3(\rho - i\eta + \frac{i}{2}\lambda^2) \\ -\lambda & 1-\frac{1}{2}\lambda^2 - i\eta\lambda^4 & A\lambda^2(1+i\eta\lambda^2) \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix}$$

ρ-η plane



$\sin 2\phi_1$

$=0.719 \pm 0.074 \pm 0.035$

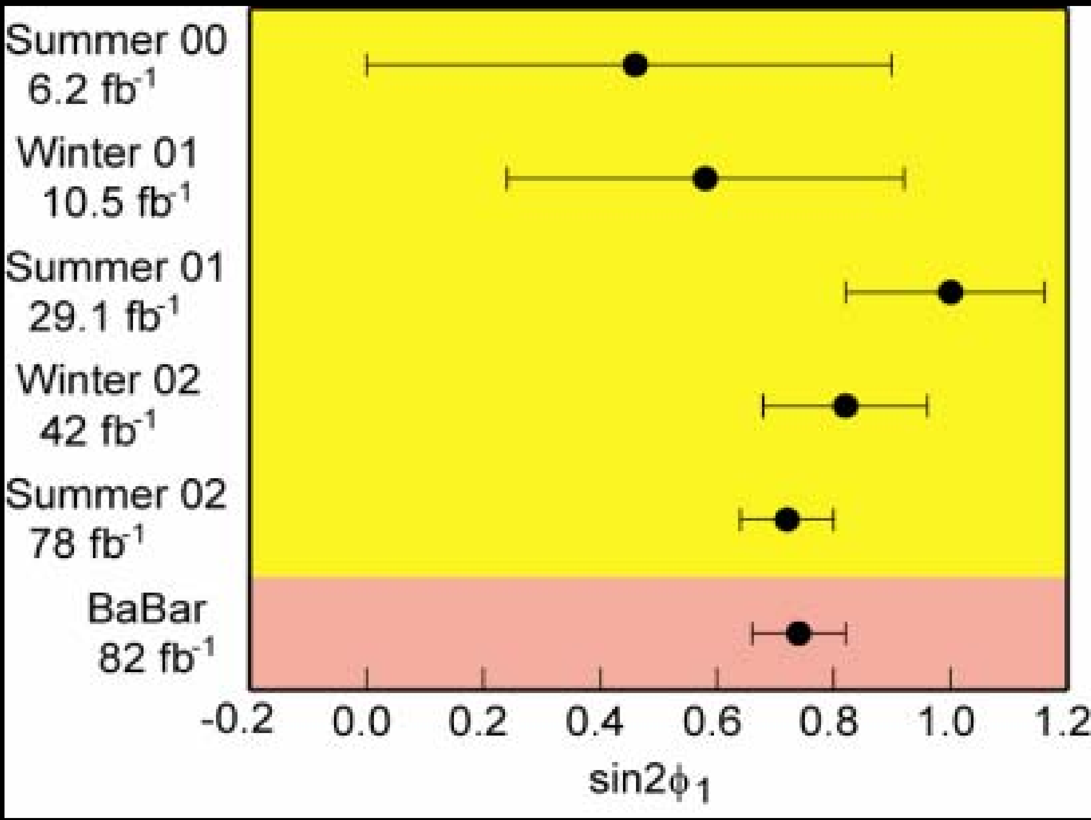
Belle July, 2002

PDG2002 (http://pdg.lbl.gov /2002/kmmixrpp)

+ New Belle result

Yamauchi KEK

History of sin2ϕ_1



Yamauchi KEK

Definition

$$A_{CP} = \frac{\Gamma(\overline{B}^0(t) \to \pi^+\pi^-) - \Gamma(B^0(t) \to \pi^+\pi^-)}{\Gamma(\overline{B}^0(t) \to \pi^+\pi^-) + \Gamma(B^0(t) \to \pi^+\pi^-)}$$

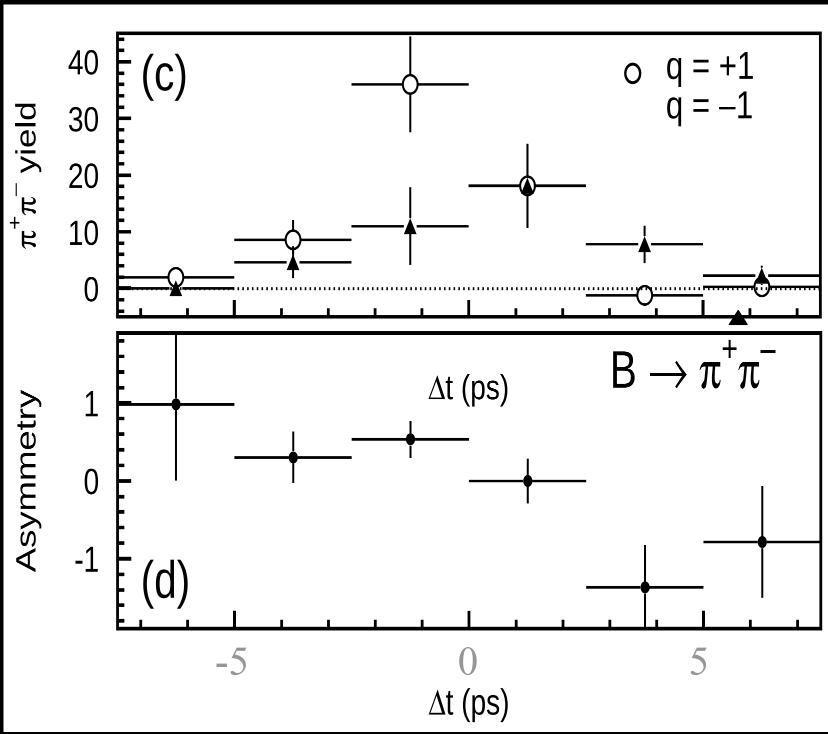
$$= S_{\pi\pi} \sin(\Delta M t) + A_{\pi\pi} \cos(\Delta M t)$$

$$S_{\pi\pi} = \frac{|\lambda_{\pi\pi}|^2 - 1}{|\lambda_{\pi\pi}|^2 + 1} \qquad \mathrm{A}_{\pi\pi} = \frac{2\,\mathrm{Im}\,\lambda_{\pi\pi}}{|\lambda_{\pi\pi}|^2 + 1}$$

$$\lambda_{\pi\pi} = \frac{M_{12}^*}{M_{12}} \frac{A(\overline{B}^0 \to \pi^+\pi^-)}{A(B^0 \to \pi^+\pi^-)}$$

$$A_{\pi\pi}{}^2 + C_{\pi\pi}{}^2 < 1$$

$S_{\pi\pi}$ and $A_{\pi\pi}$



$S_{\pi\pi} = -1.21 \pm 0.41 ^{+0.08}_{-0.07}$

$A_{\pi\pi} = +0.77 \pm 0.27 \pm 0.08$

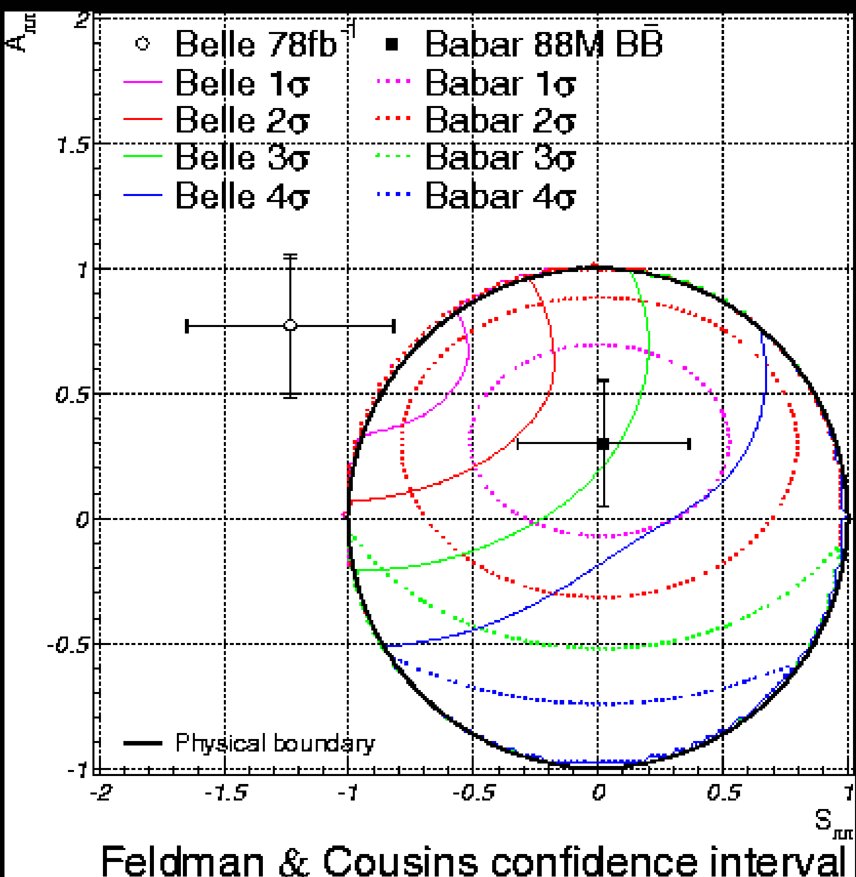
$A_{\pi\pi} \neq 0$ indicates Direct CPV

i.e., $\Gamma(B^0 \to \pi^+\pi^-) \neq \Gamma(\overline{B}^0 \to \pi^+\pi^-)$

$A_{\pi\pi} > 0$ with 99.6%CL.
$S_{\pi\pi} < 0$ with 99.6%CL.

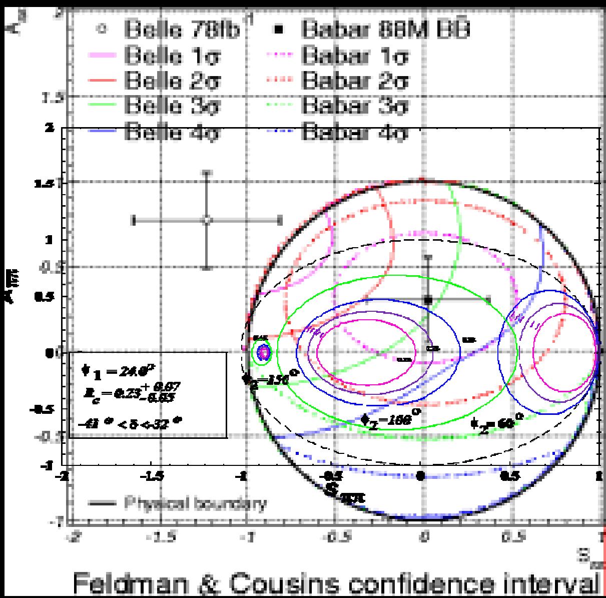
Yamauchi KEK

Comparison with BaBar's result

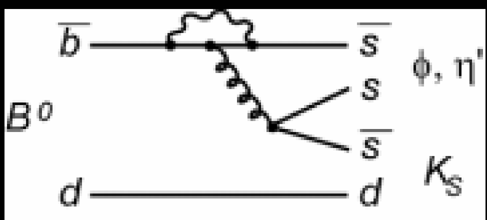


Yamauchi KEK

Comparison with Belle and BaBar



CPV in $b \rightarrow sss$



In the Standard Model,

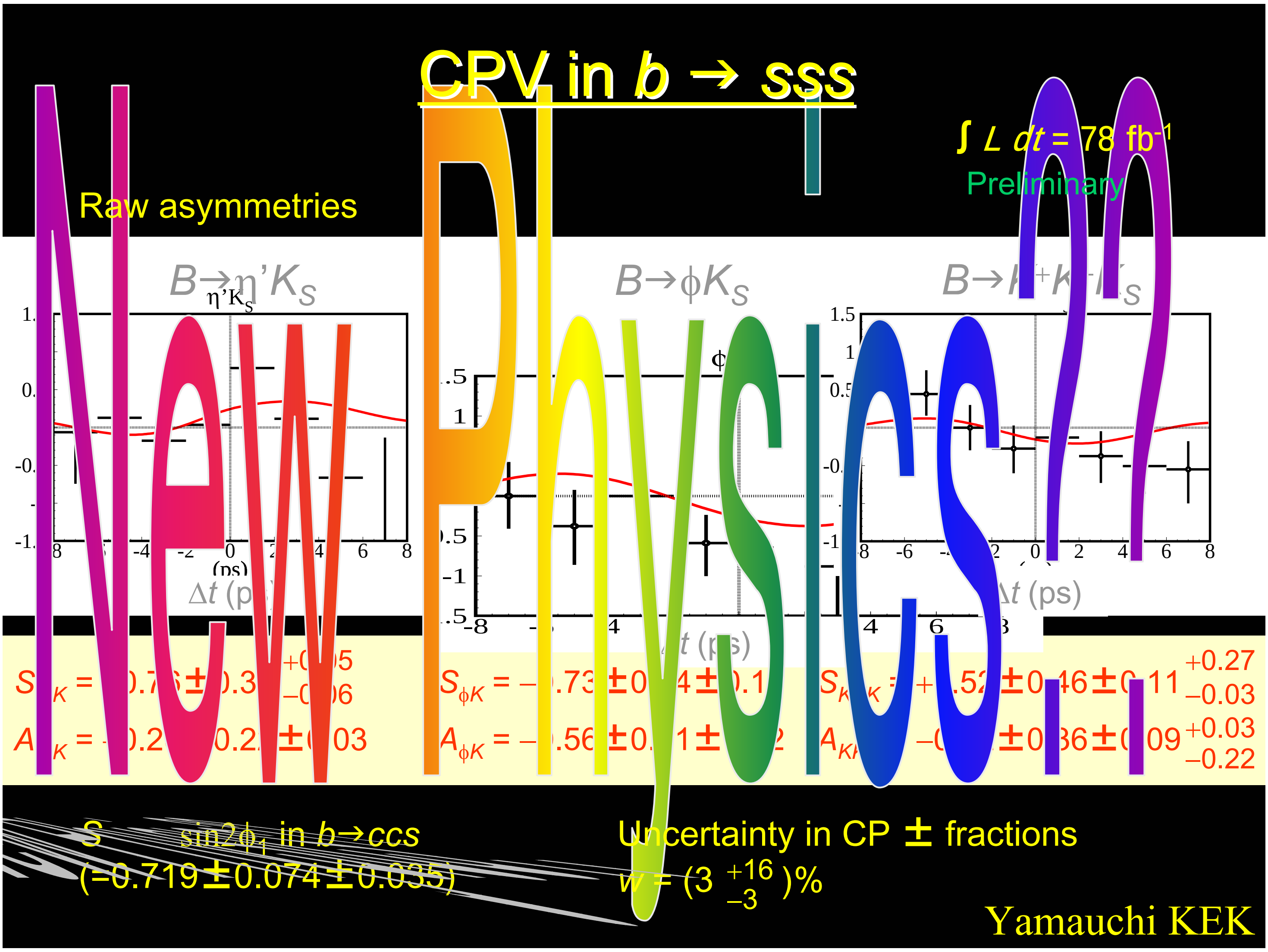
$S_{sss} = \sin 2\phi_1$ ($b \rightarrow ccs$)

$A_{sss} = \sim 0$

B($B^0 \rightarrow \eta' K^0$) = 5.8x$10^{-5}$: anomalously large

New physics contribution ??
Measure its phase.

Yamauchi KEK



Mission of Super *B* Factory(ies)

Mission 1

Precision test of KM unitarity.

> Bread'nd butter for *B* factories.

Mission 2

Search for new physics in *B* and τ decays.

> See quantum effect in penguin and box loop.

Mission 3

Identify SUSY breaking mechanism

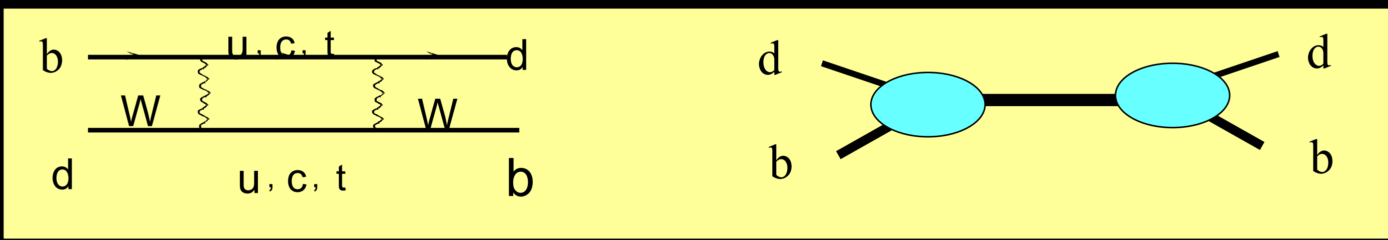
> Very important if New physics = SUSY.

New CP violation MUST exist

Baryon asymmetry
in the universe
can not be explained by
the KM ansatz.

We need more Higgs
to violate CP

This effect may show up in ΔM

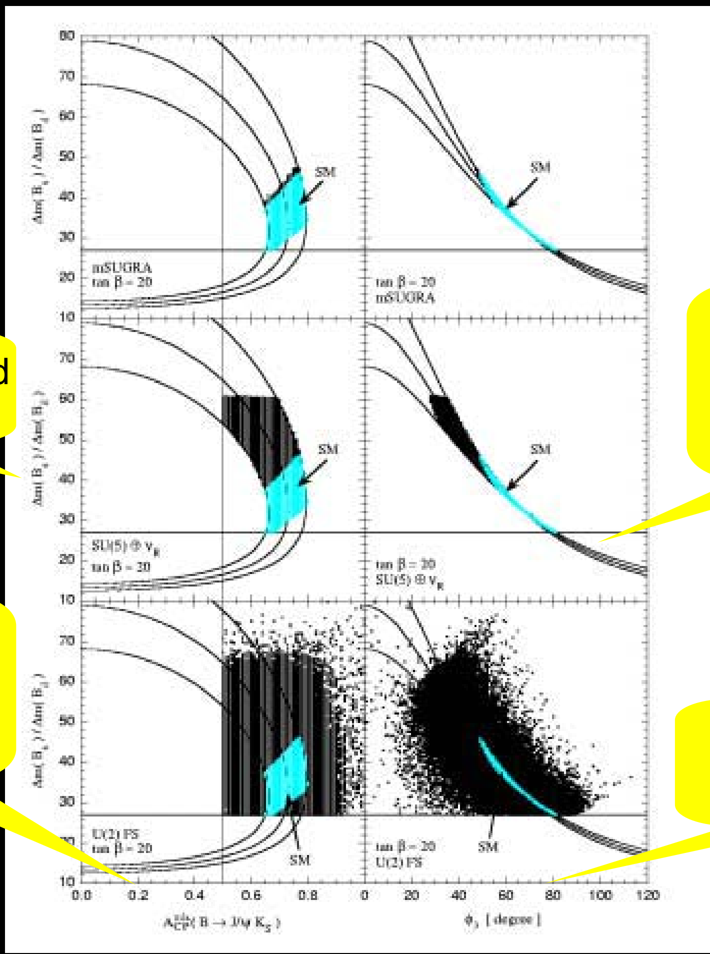


SUperSYmmetric
GrandUnified Theory
(SUSY GUT)

At least 2 Higgs and many scalar particles
are present. Easy to break CP spontaneously

Lepton number violation ocures at the GUT scale

SUSY scenario vs. *B* decays (1)



T.Goto *et al.*,
PRD:035009,02

Δm_S will be measured at Tevatron soon.

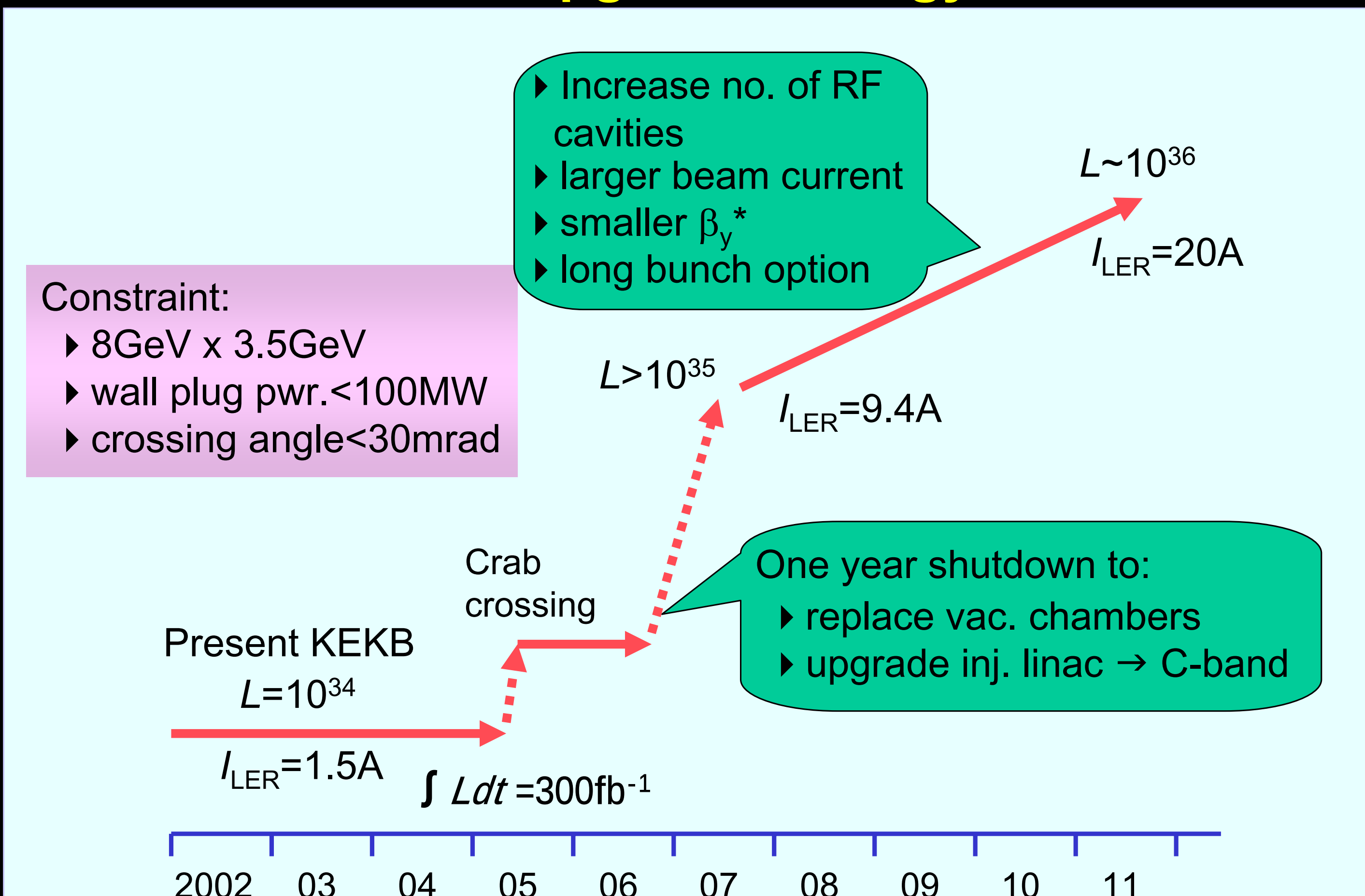
$\delta(|V_{ub}|/|V_{cb}|)$
= 0.02 (now)
→0.005(1ab^{-1})

$\delta\sin 2\phi_1$
=0.082 (now)
→0.02 (1ab^{-1})

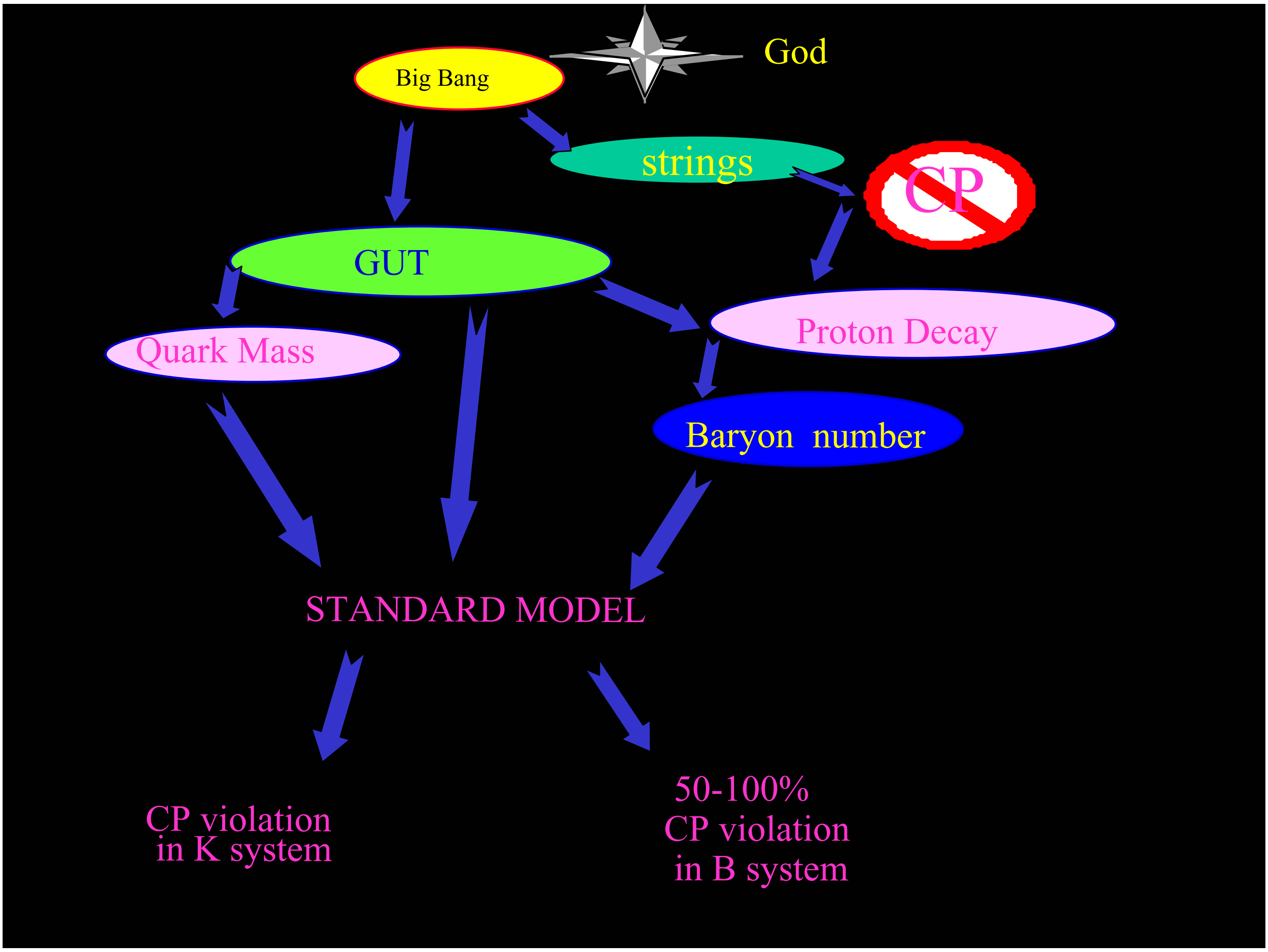
$\delta\phi_3$
→10 ° (1ab^{-1})

Yamauchi KEK

KEKB upgrade strategy



Yamauchi KEK



We don’t expect new physics effect to be sticking out at few % level. We don’t know if it will stick out at 1% level. But, if that’s the best you can do, we have to go for it!

Your window for discovery
precision measurements
in hadronic states

Conclusion

1. Much work remains after B factory.
2. Precision experiments can reveal new physics if it is out there around 1 TeV.
3. I m certain that orders of magnitude more B mesons will be available in the future.