Study of decay B→DK,D→$K_S K\pi$ for the measurement of the CP-violating angle ϕ_3

1.Motivation & Theory

CKM (Cabibbo-Kobayashi-Maskawa) Matrix

$$V = \begin{pmatrix} V_{ud} & V_{us} & V_{ub} \\ V_{cd} & V_{cs} & V_{cb} \\ V_{td} & V_{ts} & V_{tb} \end{pmatrix} = \begin{pmatrix} 1-\frac{\lambda^2}{2} & \lambda & A\lambda^3(\rho-i\eta) \\ -\lambda & 1-\frac{\lambda^2}{2} & A\lambda^2 \\ A\lambda^3(1-\rho-i\eta) & -A\lambda^2 & 1 \end{pmatrix} + \mathcal{O}(\lambda^4)$$

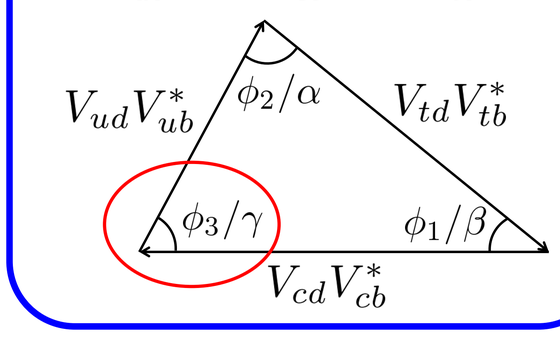
Complex terms

$$\lambda = \sin\theta_c \sim 0.22$$

Unitarity $VV^\dagger = 1$

Unitarity triangle

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



Unitarity triangle is described on complex plane, and represents CP-violation.
To understand CP-violation, the angles of this triangle should be measured precisely.

Present limits for each angle

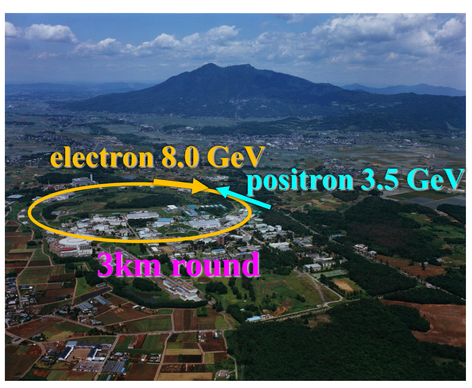
$\phi_1 = 21.15^\circ\ ^{+0.90^\circ}_{-0.88^\circ}$
$\phi_2 = 89.0^\circ\ ^{+4.4^\circ}_{-4.2^\circ}$
$\phi_3 = 71^\circ\ ^{+21^\circ}_{-25^\circ}$

ϕ_3 can be measured by examining the asymmetry between B^- and B^+ particle decays.
While B particle decays to various particles, $B^\pm$ particle which decays to D particle (D^0 or $\overline{D}^0$) and $K^\pm$ particle is used for ϕ_3 measurement.

In the present limits,
measurement accuracy of ϕ_3 is not so good.
Need to study more for ϕ_3.

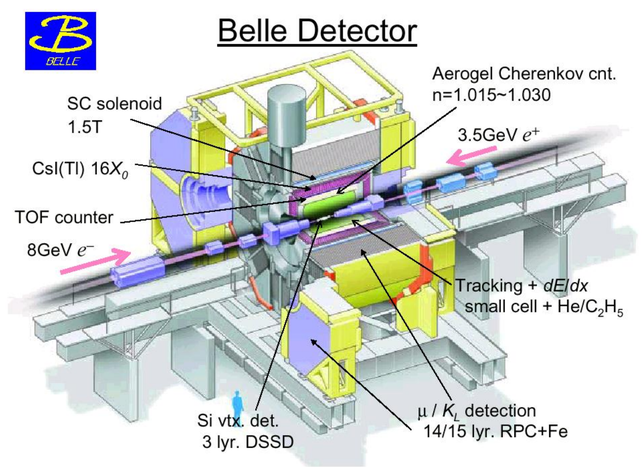
2.Facility

KEKB-factory & Belle Detector



KEK@Tukuba

- KEKB-factory is a facility to make B particles.
- High energy electrons and positrons collide, and annihilate in pairs.
- The pair annihilation produces a great deal of energy, and B particles are generated from the energy.
- There is the data of 1014 fb^{-1} which is the largest in the world.



- Belle detector is to search the decays of B particles.
- Belle detector consists of many sub-detectors, and determines the particle type, momentum, charge, and so on.

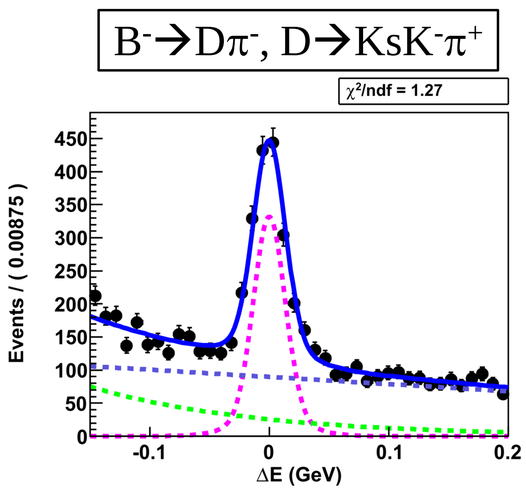
3.Analysis

- In the analysis, mother particle is reconstructed from detected particles, and it is checked whether the event is expected event from parameter (ΔE etc.) of mother particle.
- D particles also decay to various particles. In this study, D→[Ks & K & π] decay is searched.
- This mode is separated to D→Ks $K^-\pi^+$ and D→Ks $K^+\pi^-$.
- Before the B→DK search, the analysis method is confirmed by B→Dπ decay, for which the decay rate is enhanced.

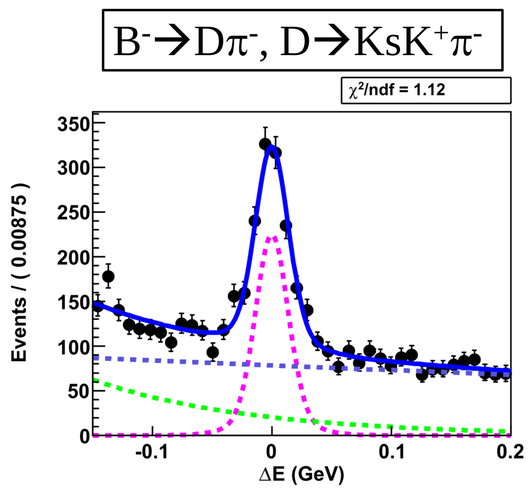
ΔE

Energy of mother particle(B) is decided by beam energy.
ΔE is the difference between the energy of reconstructed B and the beam energy.
When reconstructed B is true event, ΔE is close to zero.

B^-→Dπ$^-$, D→Ks$K^-\pi^+$



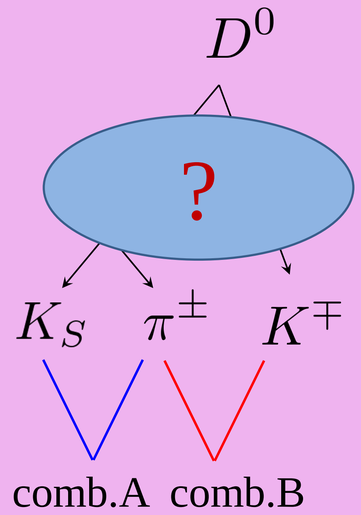
B^-→Dπ$^-$, D→Ks$K^+\pi^-$



Expected events have been detected.

Dalitz analysis

It was understood that B→Dπ, D→KsKπ can be detected (maybe B→DK can be detected also by the same method), but D decays into KsKπ via certain intermediate processes.
(e.g. D→K^{*+} K^-→[Ks π^+]$_{K^{*+}}$ K^-, D→K^{*0} Ks→[K^- π^+]$_{K^{*0}}$ Ks … etc.)
These processes should be divided.

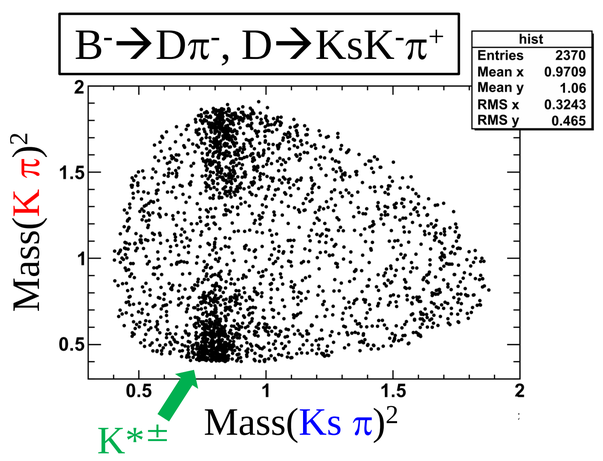


When D decays into 2 particles, and one of them continues to decay furthermore into 2 particles, the reconstructed mass of the correct pair combination yields a mass of a certain particle.

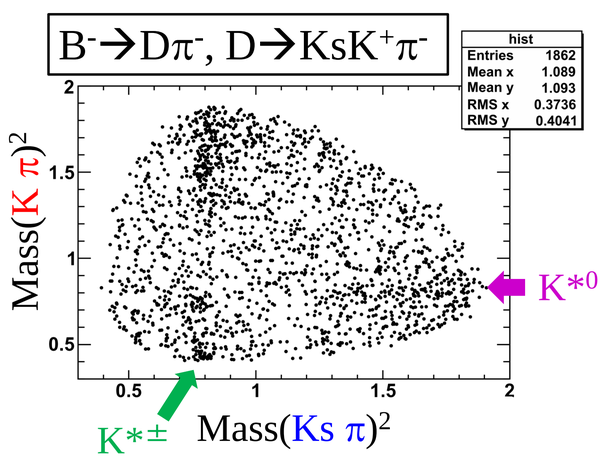
Therefore to verify intermediate states, the plot of combination A versus combination B is used. This is the so called Dalitz plot which is used to extract the value of ϕ_3.

Dalitz Plot

B^-→Dπ$^-$, D→Ks$K^-\pi^+$



B^-→Dπ$^-$, D→Ks$K^+\pi^-$



Contributions of the intermediate states appear in condensed regions.

4.Summary and Plan

- The precise measurement for ϕ_3 is important in terms of verification for CP-violation.
- B→DK decay is used in the measurement of ϕ_3, and B→Dπ is used to confirm the analysis method.
- While D decays to various particles, we use D→KsKπ with Dalitz plot.
- Need to more study Dalitz plane to understand intermediate of D→KsKπ decays.
- Of course, the final purpose is the measurement of ϕ_3 using B→DK, D→KsKπ.