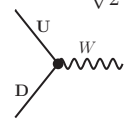
Study of $B^0 \to DK^{*0}(892)$ for ϕ_3 extraction at Belle

1. Motivation

Lagrangian of charged current weak interaction

$$\mathcal{L}_{int} = -\frac{g}{\sqrt{2}}(\bar{U}_L \gamma_\mu V_{CKM} D_L W_\mu^+) + h.c.$$



U = (u, c, t)
D = (d, s, b)
U_L, D_L : Left handed

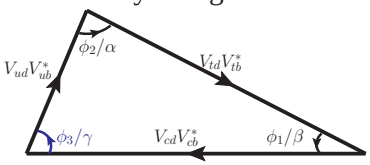
CKM(Cabbibo-Kobayashi-Masukawa) matrix

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

Unitary condition

$$V_{CKM} V_{CKM}^\dagger = 1 \xrightarrow{\text{1 row, 3 column elements}} V_{ud}V_{ub}^* + V_{cd}V_{cb}^* + V_{td}V_{tb}^* = 0$$

Unitary triangle



$\phi_1 = (21.15^{+0.90}_{-0.88})^\circ$

$\phi_2 = (89.0^{+4.4}_{-4.2})^\circ$

$\phi_3 = (68^{+13}_{-14})^\circ$

Unitarity triangle is described on complex plane, and represents CP-violation.
To understand CP-violation, the angles of this triangle should be measured precisely.
In the present limits, measurement accuracy of ϕ_3 is not so good.
Need to study more for ϕ_3.

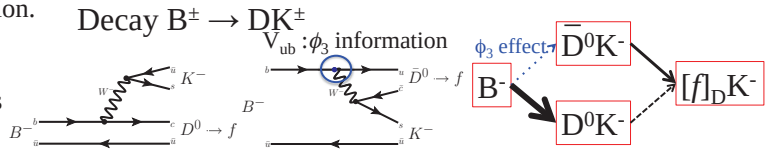
2. Analysis

$$\phi_3 \equiv \arg\left(\frac{V_{ud}V_{ub}^*}{-V_{cd}V_{cb}^*}\right) \sim -\arg(V_{ub})$$

ϕ_3 is measured with the decay include b→u transition.
e.c. $B^\pm \to D^{(*)}K^\pm$
Influence of CP violation is expected to appear due to the interference between the two amplitudes of $\bar{D}^0$ and D^0 decays into a common final state.

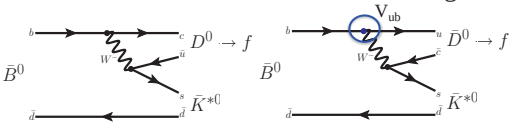
Decay $B^\pm \to DK^\pm$

V_{ub} : ϕ_3 information



Neutral B Decay $B^0 \to DK^{*0}$

1. More effect of ϕ_3
2. Less signal events → Large backgrounds

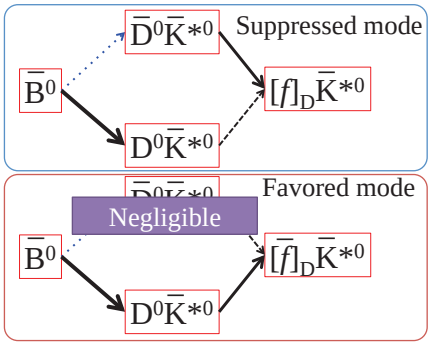


$$R_{DK^*} \cong \frac{\Gamma(B^0 \to [K^+\pi^-]_D K^{*0}) + \Gamma(\bar{B}^0 \to [K^-\pi^+]_D \bar{K}^{*0})}{\Gamma(B^0 \to [K^-\pi^+]_D K^{*0}) + \Gamma(\bar{B}^0 \to [K^+\pi^-]_D \bar{K}^{*0})}$$
$$= r_S^2 + r_D^2 + 2kr_S r_D \cos(\delta_S + \delta_D)\cos\phi_3$$

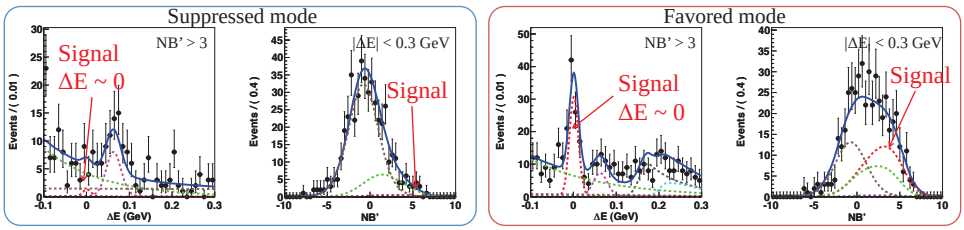
Where, I define $f = K^-\pi^+$.

Suppressed mode

Favored mode



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



I perform 2D fit for ΔE and NB'.
NB' is one of the parameter for background suppression.
In suppressed mode, there is no signal.

I obtain R_{DK^*} and 95 % C.L. upper limit.

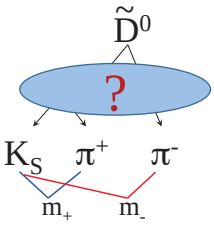
$$R_{DK^*} = (4.1^{+5.6+2.8}_{-5.0-1.8}) \times 10^{-2}$$
$$< 0.16$$

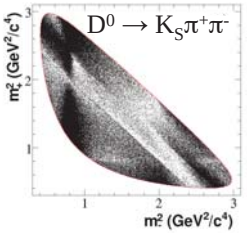
I update R_{DK^*} upper limit world record.

This R_{DK^*} indicates small r_S value.
I'll check r_S value with more sensitive way $D \to K_S\pi\pi$ Dalitz plot analysis.

3. Plan (Dalitz plot analysis)

It was understood that $B \to DK$, $D \to Ks\pi\pi$ can be detected but D decays into $Ks\pi\pi$ via certain intermediate processes.
(e.g. $D \to K^{*+}\pi^- \to [Ks\pi^+]_{K^{*+}}\pi^-$,
$D \to \rho^0 Ks \to [\pi^-\pi^+]_{\rho 0}$ Ks … etc.)
These processes should be divided.





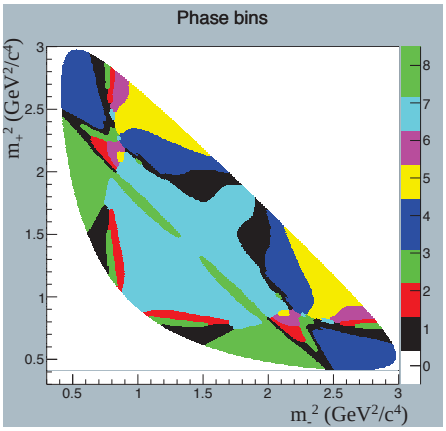
When D decays into 2 particles, and one of them continues to decay furthermore into 2 particles, the reconstructed mass of the correct pair combination yields a mass of a certain particle.

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.

This method of analysis is the first measurement of ϕ_3 using model-independent Dalitz analysis of $D \to K_S\pi^+\pi^-$ from $B^\pm \to DK^\pm$. The data sample used is 710 fb^{-1} Belle collected. In the super-B factory era, ϕ_3 with this method will be dominated by systematic error, esp. Model error.

However, the binned approach allows not only to get rid of the model error, but also to reduce the systematic uncertainties. In my analysis, I try to develop the analysis procedure that minimizes the systematic uncertainties, in view of the future high-precision analyses at the super-B factory where systematics can become a limiting factor.

In model-independent Dalitz analysis(binned method), I take account the signal events number, and obtain CP asymmetry for each bin. Each δ_D for bin is measured, it is equivalent to obtain sixteen A_{DK^*}(= $2r_S r_D \sin(\delta_S + \delta_D)\sin\phi_3/R_{DK^*}$). corresponding bin δ_D value.



One example of binning on Dalitz plot.