Search for $B \to D_s^* h$ with Belle Detector

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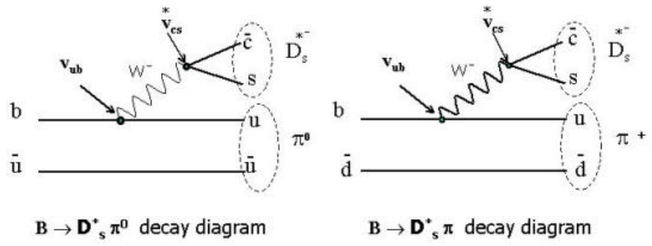
Motivation

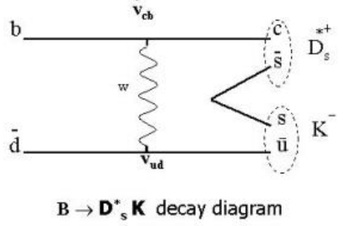


$B \to D_s^* \pi^0$ decay diagram $B \to D_s^* \pi$ decay diagram

b ® u spectator diagram

- $D_s^* \pi$ decays occur via b→u spectator diagram – clean measurement for V_{ub}
- Measuring $R^*_\lambda \propto B(B^0 \to D_s^{*+} \pi^-) / B(\bar{B}^0 \to D_s^{*-} \pi^+)$ - measurement for sin(2β+γ)
- No measurement for the branching fractions yet.

W-exchange diagram

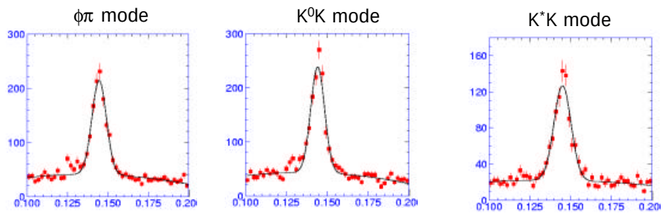


$B \to D_s^* K$ decay diagram

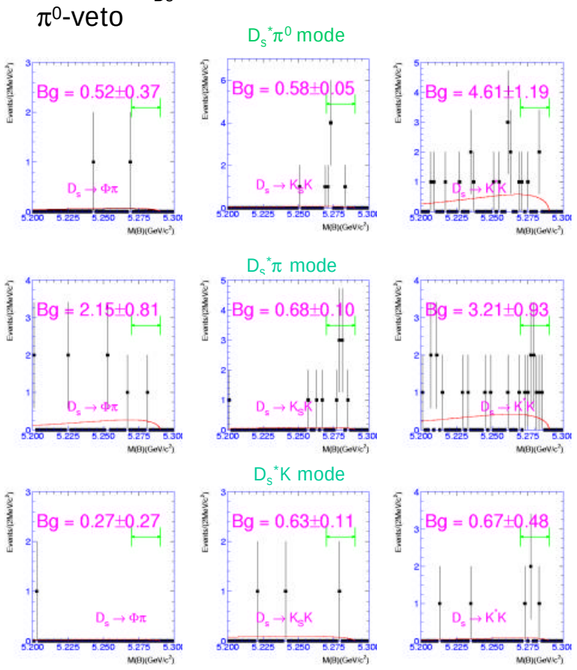
- $D_s^* K$ decay occurs via a W-exchange
- Belle has observed a similar decay $D_s K$
  - only evidence for W-exchange so far
  -PRL 89, 231804(2002)

Reconstruction of B

- φ, K_S , K^* are reconstructed by combining oppositely charged KK, ππ, Kπ pairs.
- $D_s^- \to \{\phi\pi^-, K^0K^-, K^{*0}K^-\}$
  $1.007 < M_{KK} < 1.033$ GeV/c²
  $0.812 < M_{K\pi} < 0.972$ GeV/c²
  $0.489 < M_{\pi\pi} < 0.505$ GeV/c²
- $D_s^{*-} \to D_s^- \gamma$
  $E_\gamma > 110$ MeV
  $1.8 < P_{cm} < 2.4$ GeV/c for D_s
  $1.945 < M_{Ds} < 1.985$ GeV/c²
  π^0-veto



D_s^*- D_s candidate mass difference for signal Monte Carlo for $D_s^* \pi^0$



M(B) for data for different modes with fit for the background

- $B \to D_s^* h$; $h \equiv \{\pi^0, \pi, K\}$
- $0.124 < \Delta M < 0.164$ GeV/c² where $\Delta M = M(D_s\gamma) - M(D_s)$
- We define

$$\Delta E = (\Sigma_i E_i) - E_{beam};$$

$$M(B) = \sqrt{E_{beam}^2 - (\Sigma_i \vec{P}_i)^2};$$

$\Sigma_i E_i$ = B candidate energy;
E_{beam} = beam energy in the $\Upsilon(4S)$;
$\Sigma_i P_i$ = total momentum of B in the $\Upsilon(4S)$

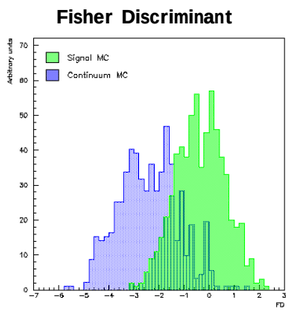
- Signal Region,

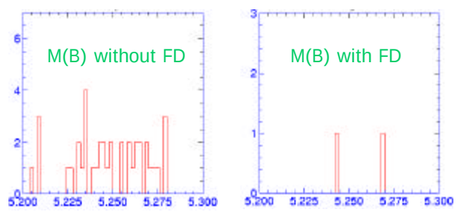
$-0.05 < \Delta E < 0.05$ GeV for $h \equiv \{\pi, K\}$
$-0.10 < \Delta E < 0.05$ GeV for $h \equiv \{\pi^0\}$
$5.27 < M(B) < 5.29$ GeV/c²

qq̄ Background Reduction

- Main source of Background comes from $e^+e^- \to q\bar{q}$ process
- We construct a Fisher Discriminant using a linear combination of 9 variables
- Fisher Discriminant is optimized to discriminate between signal and background

- $r_l = \dfrac{\Sigma_{i,j} |p_i| |p_j| P_l(\cos\theta_{ij})}{\Sigma_{i,j} |p_i| |p_j|}$; l = 1, 2, 3, 4;
- $R_l = \dfrac{\Sigma_{i,j} |p_i| |p_h| P_l(\cos\theta_{ih})}{\Sigma_{i,j} |p_i| |p_h|}$; l = 1, 2;
- $|\cos\theta_{th}|$; θ_{th}-angle between the thrust axes of B candidate and the other particles of the event
- $|\cos_B|$; B-angle between B mom. and beam axis
- -qr x Ds charge; qr contains the flavor information about the rest of the event





Beam-constrained Mass(M(B)) before and after the Fisher Discriminant selection for real data for $D_s^* \pi^0$ mode

Our Monte Carlo studies show that, we can eliminate ~85% of the background while keeping ~70% of the signal, by applying the Fisher Discriminant selection.

Reconstruction Efficiency using Signal Monte Carlo Events

mode	Sub decay of D_s	Efficiency %
$D_s^*\pi^0$	φπ	3.4±0.2
	K^0K	2.6±0.1
	K^*K	2.2±0.2
$D_s^*\pi$	φπ	5.9±0.2
	K^0K	6.6±0.2
	K^*K	5.2±0.2
D_s^*K	φπ	5.2±0.2
	K^0K	5.6±0.2
	K^*K	4.1±0.2

Background Evaluation

- Shape of the background is modeled using Monte Carlo simulated data containing generic $e^+e^- \to \Upsilon(4S) \to B\bar{B}$ and $e^+e^- \to q\bar{q}$ events and fit using a parameterized empirical background function (Phys. Lett. B241, 278 (1990)) given by

$$M_B \sqrt{1 - (M(B)/E_{beam})^2} \times \exp(-a(1 - (M(B)/E_{beam})^2); \quad a = \text{a free parameter}$$

- Fitted shapes are used to fit data in the sideband region and extrapolate to obtain an estimate for the background in the signal region.
- Possible peaking background modes such as $D^*\pi$, $D^*\pi^0$, $D\rho$, $D\pi$ are simulated to obtain estimates for the peaking backgrounds.

Observations with 152 million $B\bar{B}$ events

mode	Sub decay of D_s	Events observed	Backgrounds: generic	Backgrounds: peaking	Backgrounds: total
$D_s^*\pi^0$	φπ	0	0.52±0.37	0.001±0.002	0.52±0.37
	K^0K	6	0.58±0.05	0.19±0.18	0.77±0.19
	K^*K	4	4.61±1.19	0.36±0.20	4.97±1.21
$D_s^*\pi$	φπ	1	2.15±0.81	<0.02	2.15±0.81
	K^0K	8	0.68±0.10	0.99±0.42	1.67±0.43
	K^*K	9	3.21±0.93	0.58±0.28	3.79±0.97
D_s^*K	φπ	0	0.27±0.27	<0.02	0.27±0.27
	K^0K	1	0.63±0.11	<0.02	0.63±0.11
	K^*K	4	0.67±0.47	0.05±0.05	0.72±0.47

Results

With 65 million **$B\bar{B}$ events(2002 summer)**
$Br(B \to D_s^*\pi^0) < 1.25 \times 10^{-4}$

More results soon!