The inclusive reconstruction of Charmed mesons on B-factory

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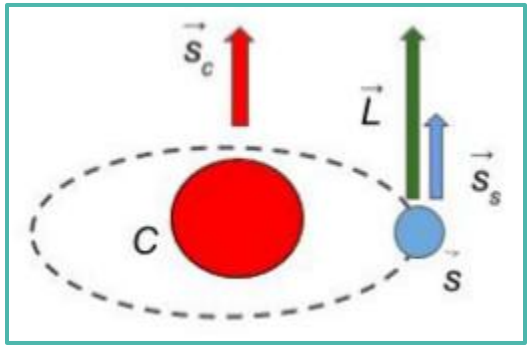
26/05/2018 **CHARM 2018**

Outline

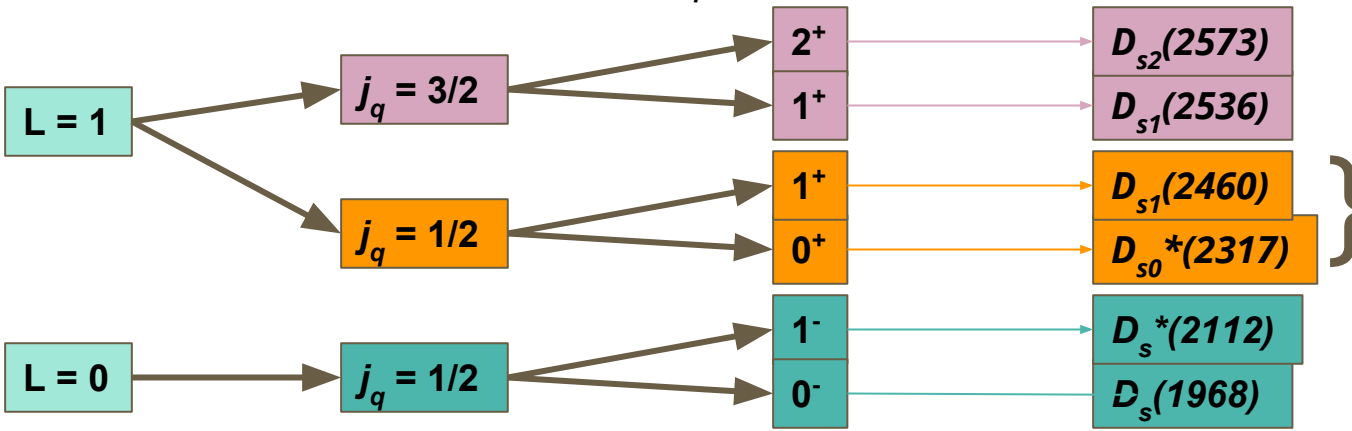
- Introduction
- Reference channels
- Fitting procedure and Cross-feeds treatment
- MC results
- Conclusions

Introduction



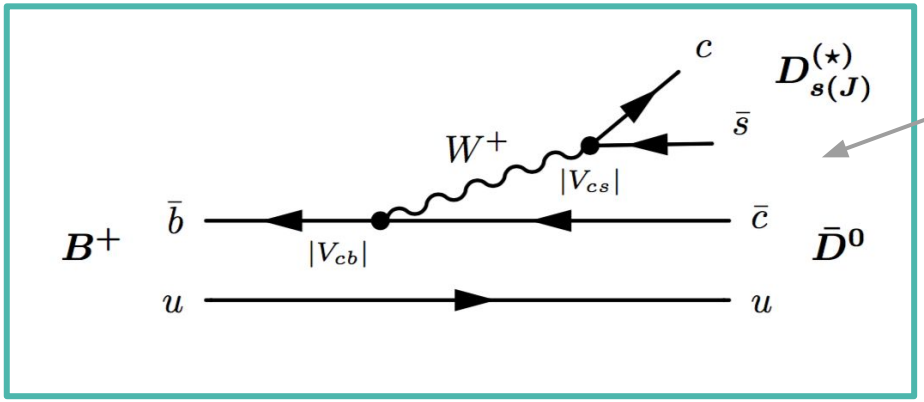
- The meson containing the heavy quark is similar to a hydrogen atom.
- At first approximation the mass of this heavy quark (***Q***) is not important in the interaction, and the properties of such type mesons depend only on the charge and mass of the light quark (***q***).
- in the limit $m_Q \to \infty$ total angular momentum of mezon is $\vec{J} = \vec{j}_q + \vec{s}_Q$

Potential models based on the heavy quarks symmetry predict for $Q\bar{q}$ system the occurrence of so-called spin doublets, classified by total momentum of light quark $\vec{j}_q$.

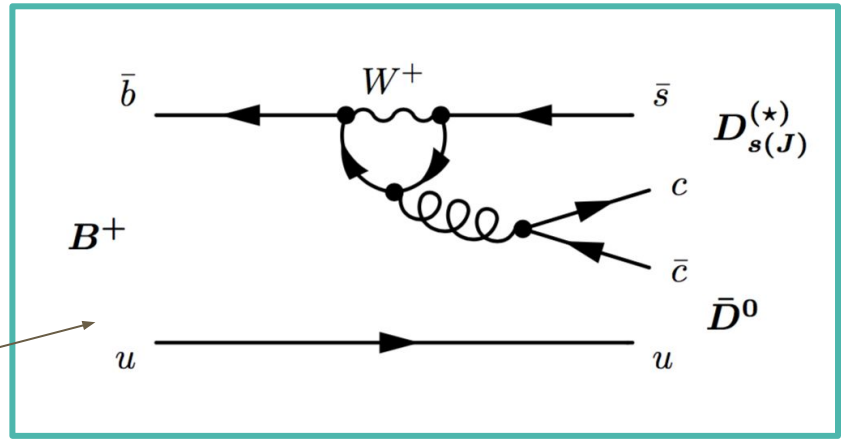


see talk
F.-K. Guo "Status of Charmed Meson Spectroscopy"

Double-charm production in B decays



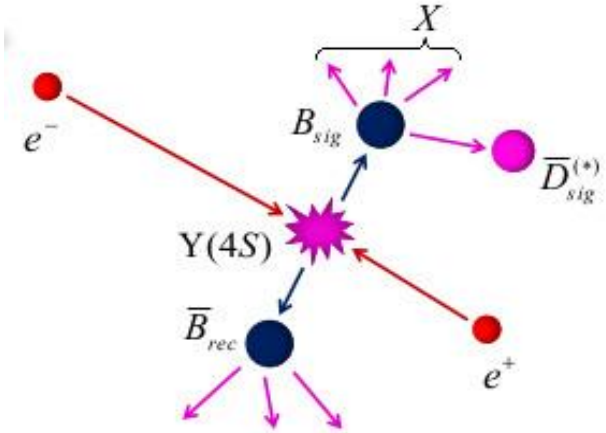
Tree diagram (dominated)



Penguin diagram (suppressed)

The $b \to c\bar{c}s$ processes are used to test the description of hadronic effects, they are also a convenient place for studying the $c\bar{s}$ spectroscopy.

Inclusive Charm reconstruction - Missing mass



D*0
D*-
D0
D-

Channels of D_{sig}^{*} reconstruction:

$D^{*-} \to D^0\pi^-$, $D^{*0} \to D^0\pi^0$
$D^{*-} \to D^-\pi^0$

Channels of D_{sig} reconstruction:

$D^0 \to K^-\pi^+$ $D^+ \to K_S^0\pi^+$
$D^0 \to K^-\pi^+\pi^+\pi^-$ $D^+ \to K^-\pi^+\pi^+$
$D^0 \to K^-\pi^+\pi^0$

Missing mass:

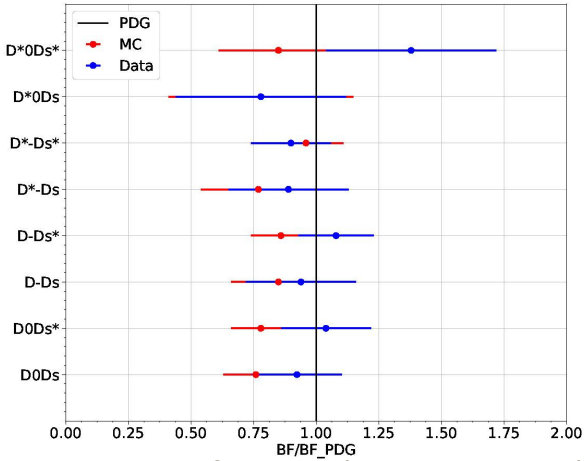
$$M_X = \sqrt{(p(Y(4S)) - p(B_{tag}) - p(D_{sig}^{(*)}))^2}$$

4-momentum of Y(4S) — 4-momentum of B_{tag} — 4-momentum of $D_{sig}^{(*)}$

Reference channels

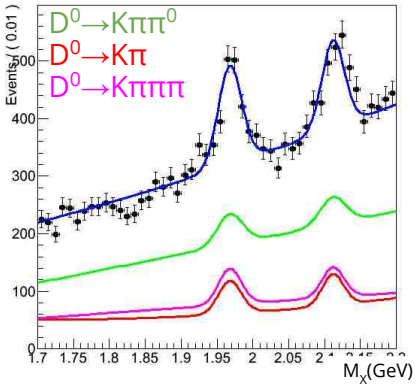
As a reference range was taken the missing mass range M_X 1.7 - 2.2 GeV, in which there are well known decay channels

$B \rightarrow D^{(*)}D_s$, $B \rightarrow D^{(*)}D^*$, $B \rightarrow D^{(*)}D_s^*$.

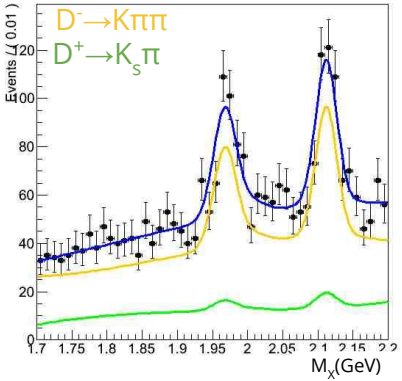


Comparison of Data and MC to PDG results

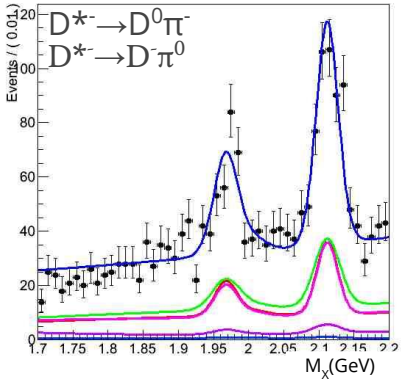
Results for Data based on the full Belle data set



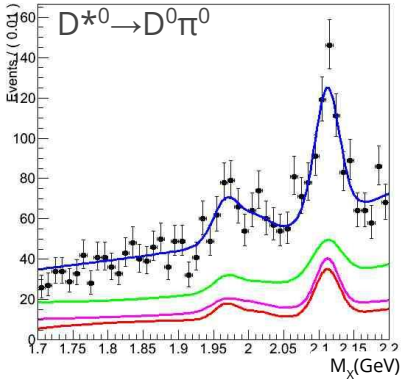
$B^- \rightarrow D^0 D_{(s)}^{(*)}$



$B^0 \rightarrow D^- D_{(s)}^{(*)}$

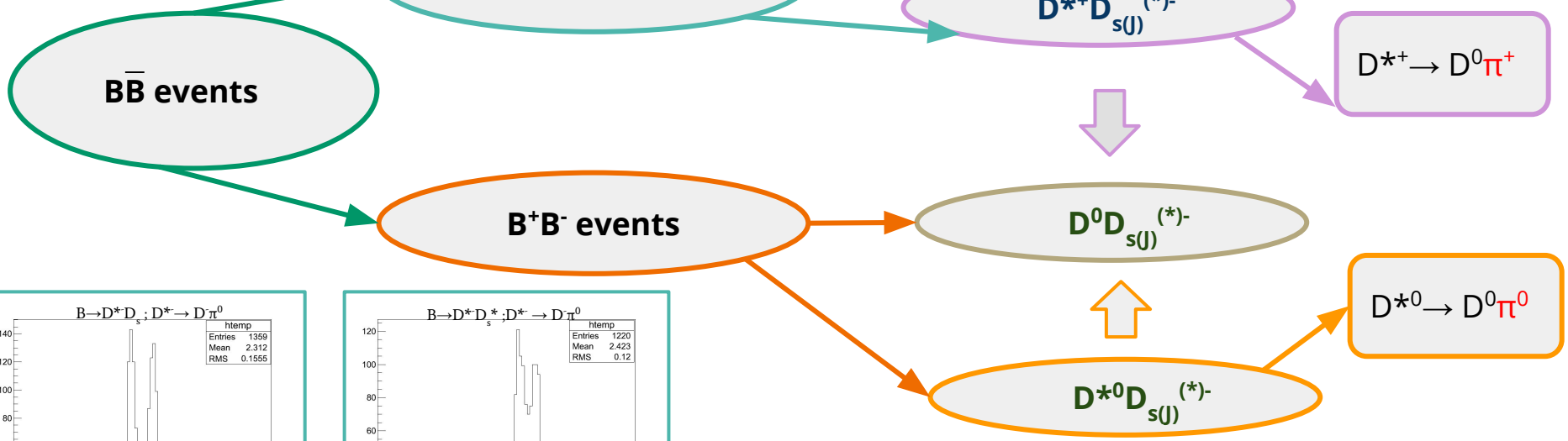


$B^0 \rightarrow D^{*-} D_{(s)}^{(*)}$



$B^- \rightarrow D^{*0} D_{(s)}^{(*)}$

Cross-feeds


$B\bar{B}$ events
B^0B^0 events
B^+B^- events
$D^+D_{s(J)}^{(*)-}$
$D^{*+}D_{s(J)}^{(*)-}$
$D^0D_{s(J)}^{(*)-}$
$D^{*0}D_{s(J)}^{(*)-}$
$D^{*+} \rightarrow D^+\pi^0$
$D^{*+} \rightarrow D^0\pi^+$
$D^{*0} \rightarrow D^0\pi^0$

$B \rightarrow D^{*-}D_s$; $D^{*-} \rightarrow D^-\pi^0$
htemp
Entries 1359
Mean 2.312
RMS 0.1555
D_s
mx

$B \rightarrow D^{*-}D_s^*$; $D^{*-} \rightarrow D^-\pi^0$
htemp
Entries 1220
Mean 2.423
RMS 0.12
D_s^*
mx

Fitting procedure

To determine the number of $B \to D^{(*)} D_{s(J)}^{(*)}$ signal events and its shape parameters the fit performed by the simultaneous unbinned extended maximum likelihood method (UEML fit) event by event was used for the M_X variable taking into account the cross-feeds between individual decay channels.

Probability density functions for the signal: $PDF_{Si} = Gauss^{i}(M_{Xi}^{j})$;

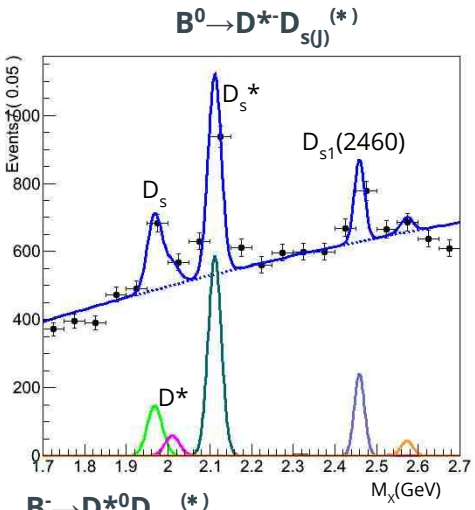
background: $PDF_{bkg}^{\ i} = Cheb^{i}_{1,2,3}(M_{Xi}^{j})$; and cross-feeds: $PDF_{x\text{-}feed}^{\ i \to k} = f_{x\text{-}feed}^{\ i}(M_{Xk}^{j})$;

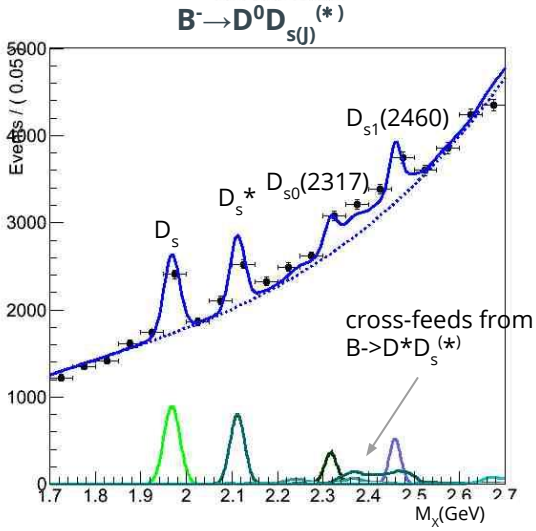
The probability function taking into account normalized PDF functions has the following form:

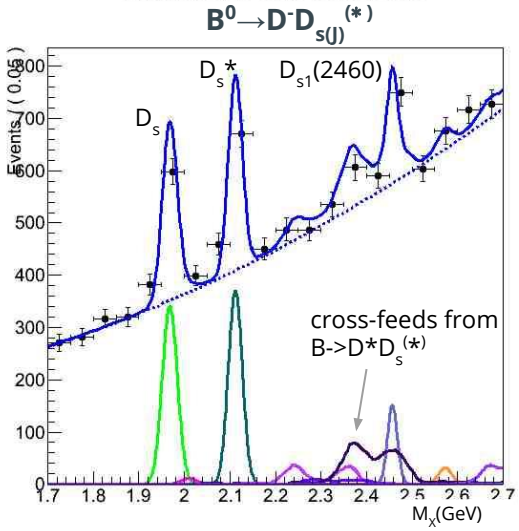
$$\mathcal{L} = \frac{(N_{sig} + N_{bkg})^N \cdot e^{(N_{sig}+N_{bkg})}}{N} \prod_{j=1}^{N} \Big(\sum_i \big(N_{sig}^{i \to i}(\mathcal{B}_i) \cdot PDF_{S_i}(M_{X_i}^j) + N_{bkg}^i \cdot PDF_{bkg}^i(M_{X_i}^j) + \sum_k N_{sig}^{i \to k}(\mathcal{B}_i) \cdot PDF_{x-feed}^{i \to k}(M_{X_k}^j) \big) \Big),$$

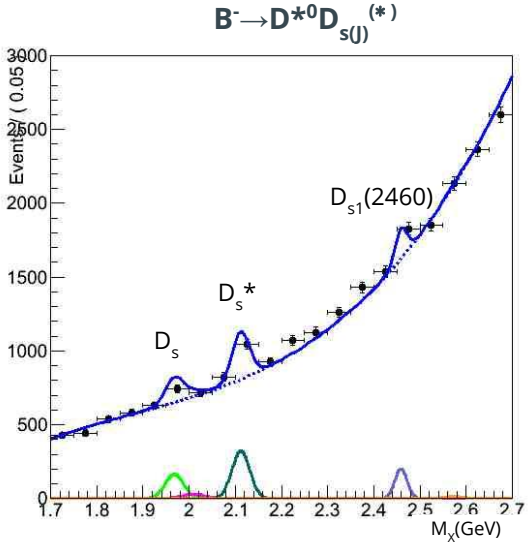
MC results

Results of fitting MC to the missing mass distribution in whole examining range, taking to account the cross-feeds between individual channels of D mesons decays.









Numerical results for MC in the range 1.7 - 2.7 GeV

B^+ Decays	$\mathcal{B}$ GMC [%]
$B^+ \to \bar{D}^0 D_s^+$	0.66 ± 0.05
$B^+ \to \bar{D}^0 D_s^{*+}$	0.58 ± 0.05
$B^+ \to \bar{D}^0 D_{s0}^*(2317)^+$	0.24 ± 0.05
$B^+ \to \bar{D}^0 D_{s1}(2460)^+$	0.30 ± 0.05
$B^+ \to \bar{D}^0 D_{s2}^*(2573)^+$	0.013 ± 0.016
$B^+ \to \bar{D}^{*0} D_s^+$	0.77 ± 0.18
$B^+ \to \bar{D}^{*0} D^{*+}$	0.22 ± 0.17
$B^+ \to \bar{D}^{*0} D_s^{*+}$	1.70 ± 0.12
$B^+ \to \bar{D}^{*0} D_{s0}^*(2317)^+$	0.013 ± 0.026
$B^+ \to \bar{D}^{*0} D_{s1}(2460)^+$	0.71 ± 0.12
$B^+ \to \bar{D}^{*0} D_{s2}^*(2573)^+$	0.18 ± 0.11

B^0 Decays	$\mathcal{B}$ GMC [%]
$B^0 \to D^- D_s^+$	0.66 ± 0.06
$B^0 \to D^- D^{*+}$	0.020 ± 0.016
$B^0 \to D^- D_s^{*+}$	0.663 ± 0.066
$B^0 \to D^- D_{sJ}(2457)^+$	0.196 ± 0.059
$B^0 \to D^{*-} D_{sJ}(2573)^+$	0.07 ± 0.05
$B^0 \to D^{*-} D_s^+$	0.64 ± 0.10
$B^0 \to D^{*-} D^{*+}$	0.20 ± 0.09
$B^0 \to D^{*-} D_s^{*+}$	1.70 ± 0.12
$B^0 \to D^{*-} D_{sJ}(2460)^+$	0.71 ± 0.12
$B^0 \to D^- D_{sJ}(2573)^+$	0.175 ± 0.112

Conclusions and prospects

- On Belle data we can improve the BF measurements by reducing statistical and systematic uncertainties by factor 3 in respect to the current measurements.
- On Belle II data (50 times more) we can study the properties of higher excited states of $D_{s(J)}^{(*)}$ mesons.
- Further improvement can come from the including in the simultaneous fit D** mesons.
- With the similar method we can study recoil mass in respect to D_s hence reconstruct inclusively $D^{(**)}$ mesons.

Backup

Decay channel	PDG	Inclusive results
$B^+ \to D^0 D_{s1}(2460)$	0.31 ± 0.1	0.43 ± 0.16 ± 0.13
$B^+ \to D^{*0} D_{s1}(2460)$	1.2 ± 0.3	1.12 ± 0.26 ± 0.20
$B^0 \to D^- D_{s1}(2460)$	0.35 ± 0.11	0.26 ± 0.15 ± 0.07
$B^0 \to D^{*-} D_{s1}(2460)$	0.93 ± 0.22	0.88 ± 0.20 ± 0.14