The measurement of branching ratio of $B_s^0 \to D_s^{\mp} K^{\pm}$ and $B_s^0 \to D_s^- \pi^+$ in the LHCb experiment

Agnieszka Dziurda
on behalf of the LHCb collaboration

Institute of Nuclear Physics PAS, Cracow
Cracow University of Technology, Cracow

agnieszka.dziurda@cern.ch

11.01.2011

Outline

- Introduction
  - Overview LHCb studies related to $B \to DX$ decays
- Selection
  - Kinematic selection
  - Geometric selection
  - Particle Identification
- Results
  - The mass fit for $B_s^0 \to D_s^- \pi^+$, $B_s^0 \to D_s^{\mp} K^{\pm}$ modes
  - Measurements of branching ratio
- Conclusions and plans

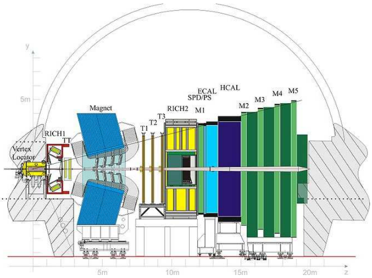
For more details look at LHCb-CONF-2011-057.

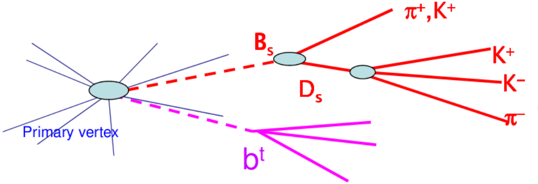
Overview LHCb studies related to $B \to DX$ decays

Decay mode/ analysis	Measurement(s)
ADS/GLW analysis	γ
GGSZ model-dependent/-independent analyses	γ
Dalitz analysis with $B \to DK\pi$	γ
$B^0 \to D^0 K^*$, $B_s \to D^0 \phi$	γ
Time-dependent CP violation in $B_s \to D_s K$	A_{CP}, γ
Time-dependent CP violation in $B_s \to D_s K\pi\pi$	A_{CP}, γ
B^0, B_s and relative lifetime measurements	test HQET
Branching ratio measurements	$BR(B^0 \to DK)/BR(B^0 \to D\pi)$
Observations of rare modes: $B_s \to DK/\pi$	exchange/annihilation topologies
$B^0 \to D\pi$, $B_s \to D_s\pi$	$\Delta m_d, \Delta m_s$
Ratio of yields in $B^0 \to DK$ and $B_s \to D_s\pi$	f_d/f_s

(f_d/f_s) measurements $\to$ see Piotr Morawski's presentation
CPV in b system $\to$ see Aurelien Martens' presentation

The analysis is based on *pp collision data sample of* $336pb^{-1}$ *collected at LHC in 2011 at the center-of-mass energy* $\sqrt{s} = 7\,TeV$.



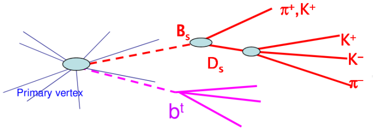


Both decay modes $B_s^0 \rightarrow D_s^- \pi^+$ and $B_s^0 \rightarrow D_s^{\mp} K^{\pm}$ are topologically identical and are selected using identical geometric and kinematic criteria.

Event selection

Trigger

- L0 selects a high transverse energy deposit
- HLT uses a bonsai boosted decision tree (BBDT)



Preselection

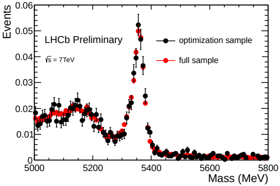
- well-reconstructed tracks for all particles
  - track $\chi^2/ndf < 4$
  - transverse momentum ($p_T > 250$ [MeV/c])
  - the impact parameter χ^2 w.r.t. the primary vertex > 4
  - max. the impact parameter χ^2 w.r.t. the primary vertex > 40
- the flight distance χ^2 of the D_s^+ from the $B_s^0 > 2$
- vertex $\chi^2/ndf < 9$ for D_s^+ and B_s^0 mesons
- $cos(\theta_{flight}) > 0.9999$ where θ_{flight} is the angle between the B_s^0 momentum vector and its direction of flight
- χ^2 of impact parameter w.r.t. the primary vertex < 16 for B_s^0 meson

Offline selection

Event selection: offline selection

The offline selection uses the gradient boosted decision tree (BDTG), which is one of the multivariative selection.

To not bias the results for decay mode only 10% of the full data sample is used in this optimization.



The optimal working point is chosen by evaluating the signal significance with respect to the combinatoric background:

$$Sig_{D_s K} = \frac{S_{D_s \pi}/14}{\sqrt{S_{D_s \pi}/14 + B}} \quad (1)$$

At the minimal BDTG value of 0.1, a significance of 4.4 is obtained corresponding to a reduction of the signal yield of 6% with a background reduction of 45%.

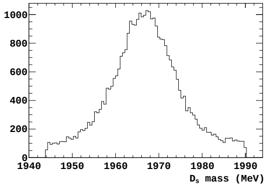
Particle Identification

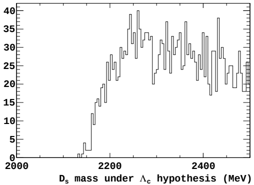
Notation: $DLL(X-Y)$ - the difference in log-likelihood between X and Y hypothesis

	$B_s \to D_s\pi$	$B_s \to D_sK$
bachelor	$DLL(K-\pi) < 0$	$DLL(K-\pi) > 5$
π^- from D_s^-	$DLL(K-\pi) < 5$	$DLL(K-\pi) < 5$
K^+ from D_s^-	$DLL(K-\pi) > 0$	$DLL(K-\pi) > 0$
K^- from D_s^-	$DLL(K-\pi) > 5$	$DLL(K-\pi) > 5$

Removing $\Lambda_b \to \Lambda_c^+\pi^-$, $\Lambda_c^+ \to pK^-\pi^+$ contamination

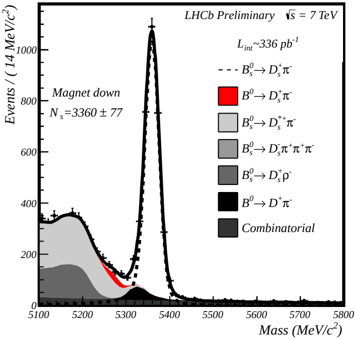
- $DLL(K-p) > 0$ for the kaon which has the same charge as the pion in $D_s \to KK\pi$
- the candidates had not to fall under the $\Lambda_c^+ \to pK^-\pi^+$ mass hypothesis (defined as ± 21 [MeV/c^2] around the nominal value of 2285 [MeV/c^2])

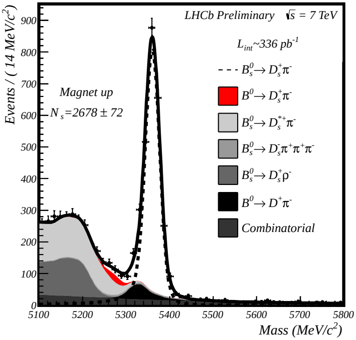




$B_s \to D_s\pi$ mass fit

Parameter	Mag. down	Magnet Up
Num. combinatorics	860 ± 150	790 ± 230
Num. part. reco.	3200 ± 100	2420 ± 120
Num. $B_s^0 \to D_s^- \pi^+$	3360 ± 77	2678 ± 72
$B_s^0 \to D_s^- \pi^+$ mass mean [MeV$/c^2$]	5259.4 ± 0.4	5360.4 ± 0.5

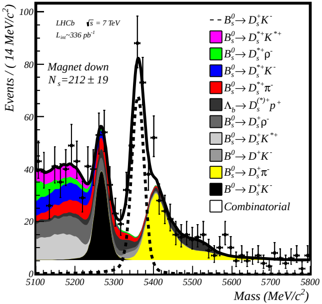


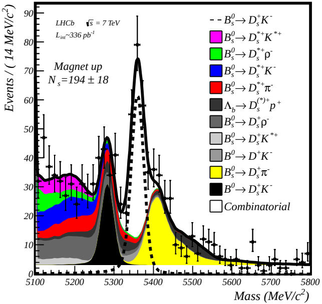


$B_s \to D_s K$ mass fit

Parameter	Mag. down	Magnet Up
Num. $B^0 \to D_s^- K^+$	150 ± 18	91 ± 17
Num. $B_s^0 \to D_s^- \pi^+$ and $B^0 \to D^- \pi^+$	161 ± 22	158 ± 21
Num. $B_s^0 \to D_s^\mp K^\pm$	221 ± 19	195 ± 18
$B_s^0 \to D_s^\mp K^\pm$ mass mean [MeV/c^2]	5360.8 ± 1.8	5359.7 ± 1.8

Many contributing sources of background





Measurements of branching ratios $B \longrightarrow D_s h$

$$\frac{B(B_s^0 \rightarrow D_s^{\mp} K^{\pm})}{B(B_s^0 \rightarrow D_s^- \pi^+)} = 0.0647 \pm 0.0044(stat.)^{+0.0039}_{-0.0043}(syst.) \qquad (2)$$

$$B(B_s^0 \rightarrow D_s^- \pi^+) = (3.04 \pm 0.19(stat.) \pm 0.23(syst.)^{+0.18}_{-0.16}(f_s/f_d))x10^{-3} \quad (3)$$

$$B(B_s^0 \rightarrow D_s^{\mp} K^{\pm}) = (1.97 \pm 0.18(stat.)^{+0.19}_{-0.20}(syst.)^{+0.11}_{-0.10}(f_s/f_d))x10^{-4} \quad (4)$$

The world's most precise measurements!

Source	Uncertainty
Generator efficiency	3%
All non-PID selection	3%
Fit model $B_s^0 \rightarrow D_s^- \pi^+$	0.9%
Fit model $B_s^0 \rightarrow D_s^{\mp} K^{\pm}$	+4%,−5%
PID selection	0.9%
Total	+5.9%, −6.7%

Conclusions and plans

- First observation of the $B_s \rightarrow D_s K$ decay at LHCb.
- The world's most precise measurements of the $B_s \rightarrow D_s h$ branching ratios!

- In 2011 $O(fb^{-1})$ data were collected, 1300-1500 $B_s \rightarrow D_s K$ events expected.
- Preliminary results on time dependent CP measurements with $D_s h$ and Dh can be expected at Winter/Spring conferences 2012.

  First measurements of this kind from a hadron machine.

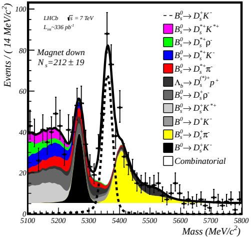
- Other results are expected: $B_s \rightarrow D_s \pi$ lifetime, updates of $BF's$ and f_s/f_d measurements.

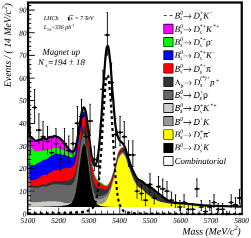
Thank You

$B_s \to D_s K$ mass fit

Parameter	Mag. down	Magnet Up
Num. $B^0 \to D_s^- K^+$	150 ± 18	91 ± 17
Num. $B_s^0 \to D_s^- \pi^+$ and $B^0 \to D^- \pi^+$	161 ± 22	158 ± 21
Num. $B_s^0 \to D_s^{\mp} K^{\pm}$	221 ± 19	195 ± 18
$B_s^0 \to D_s^{\mp} K^{\pm}$ mass mean [MeV/c^2]	5360.8 ± 1.8	5359.7 ± 1.8

Background type	Mag. down	Mag. Up
$B_s^0 \to D_s^{*-} \pi^+$	70 ± 23	63 ± 21
$B_s^0 \to D_s^{*-} K^+$	80 ± 27	72 ± 34
$B_s^0 \to D_s^- \rho^+$	150 ± 50	135 ± 45
$B_s^0 \to D_s^- K^{*+}$	150 ± 50	135 ± 45
$B_s^0 \to D_s^{*-} \rho^+$	50 ± 17	45 ± 15
$B_s^0 \to D_s^{*-} K^{*+}$	50 ± 17	72 ± 15
$\Lambda_b \to D_s^{(*)-} p$	80 ± 27	72 ± 34





The $B_s^0 \to D_s^{\mp} K^{\pm}$ branching fraction relative to $B_s^0 \to D_s^- \pi^+$

$$\frac{B(B_s^0 \to D_s^{\mp} K^{\pm})}{B(B_s^0 \to D_s^- \pi^+)} = \frac{N_{B_s^0 \to D_s^{\mp} K^{\pm}}}{N_{B_s^0 \to D_s^- \pi^+}} \frac{\epsilon^{\mathrm{PID}}_{B_s^0 \to D_s^- \pi^+}}{\epsilon^{\mathrm{PID}}_{B_s^0 \to D_s^{\mp} K^{\pm}}} \frac{\epsilon^{\mathrm{Sel}}_{B_s^0 \to D_s^- \pi^+}}{\epsilon^{\mathrm{Sel}}_{B_s^0 \to D_s^{\mp} K^{\pm}}}. \quad (5)$$

where $N_{B_s^0 \to D_s^{\mp} K^{\pm}} = 406 \pm 26$, $N_{B_s^0 \to D_s^- \pi^+} = 6038 \pm 105$,
$\epsilon^{\mathrm{PID}}_{B_s^0 \to D_s^{\mp} K^{\pm}} = 83.4 \pm 0.2$ $\epsilon^{\mathrm{PID}}_{B_s^0 \to D_s^- \pi^+} = 85.1 \pm 0.2$.

$$\frac{\epsilon^{\mathrm{Sel}}_{B_s^0 \to D_s^- \pi^+}}{\epsilon^{\mathrm{Sel}}_{B_s^0 \to D_s^{\mp} K^{\pm}}} = 0.945 \pm 0.014$$

The branching fraction of $B_s^0 \to D_s^- \pi^+$

$$B(B_s^0 \to D_s^- \pi^+) = B(B^0 \to D^- \pi^+) \frac{\epsilon_{B^0 \to D^- \pi^+}}{\epsilon_{B_s^0 \to D_s^- \pi^+}} \frac{N_{B_s^0 \to D_s^- \pi^+}}{\frac{f_s}{f_d} N_{B^0 \to D^- \pi^+}} X$$

$$X \frac{B(D^+ \to K^- \pi^+ \pi^+)}{B(D_s^+ \to K^+ K^- \pi^+)}$$