Observation of the $B_s^0 \to \bar{D}^0 K^+ K^-$

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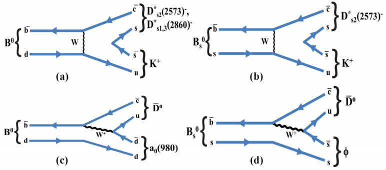
Yellow pages

⇛ Proponents: Vincent Tisserand, Stephane T'Jampens, Wenbin Qian, Nicolas Déléage
⇛ Reviewers: Mark Whitehead (chair), Anton Poluektov
⇛ EB: Fred Blanc
⇛ EB readers: Franco Bedeschi, Mitesh Patel
⇛ Twiki: `https://twiki.cern.ch/twiki/bin/view/LHCPhysics/B02D0KK`
⇛ Jurnal: PRD.

⇛ Deadline for comments: 9^{th} May.
⇛ Please send me comments before: 8^{th} May.

Physics in the paper

⇛ Observation of $B_s^0 \to \bar{D}^0 K^+ K^-$.
⇛ Precise determination of $B \to \bar{D}^0 K^+ K^-$.
⇛ Limited physics applications so far.
⇛ Future possible measurement of γ angle.



Analysis strategy

⇛ We look for $B_s^0/B^0 \to \bar{D}^0 K^+ K^-$.
⇛ Normalize the decay to: $B^0 \to \bar{D}^0 \pi^+ \pi^-$.
⇛ Run1 analysis ($3\ \mathrm{fb}^{-1}$).
⇛ The branching fraction is relativity well known:
$\mathcal{B}(B^0 \to \bar{D}^0 \pi^+ \pi^-) = (8.8 \pm 0.5) \times 10^{-4}$ [1]
⇛ For B_s^0 us f_s/f_d.

[1] The decay normally is dominated by $B \to D^* \pi$, which is vetod.

MVA

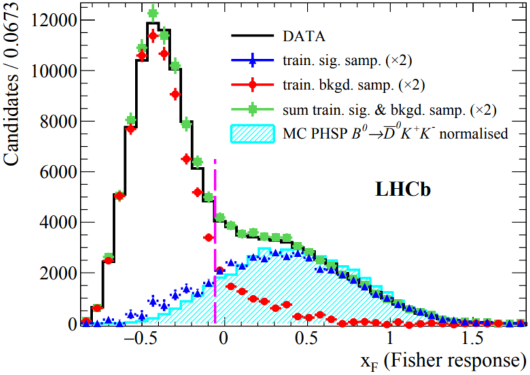
⇛ Data driven method to get MVA: $B \to \bar{D}\pi\pi$ as signal proxy sweighted. (the good).

⇛ The bad:

To compute the *sWeights*, the signal and combinatorial background yields are determined using an unbinned extended maximum likelihood fit to the invariant mass distribution of B^0 candidates. The fit uses a Crystal Ball (CB) function [41] and a Gaussian function for the signal distribution and an exponential function for the combinatorial background distribution in the mass range of $[5240; 5420]$ MeV/c^2. To compute the *sWeights*, the above fit is repeated within the signal region $[5240;\ 5320]$ MeV/c^2 with all the parameters fixed to the result of the initial fit, except the number of the signal and the background events, which are found to be $44,695 \pm 537$ and $81,708 \pm 570$, respectively and correspond to a signal purity of $(35.4 \pm 0.6)\%$. The distributions of the discriminating

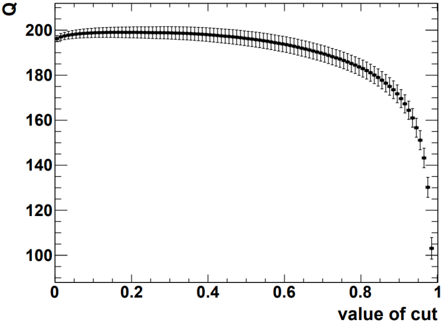
MVA

⇛ The good: they identified at the beginning 14 "standard" variables for MVA.
⇛ Removed the lest sensitive variables and ended up 5 variables with minimal loose of discriminating power.
⇛ BDT, MLP tried. Fisher has similar performance and was used.



PID

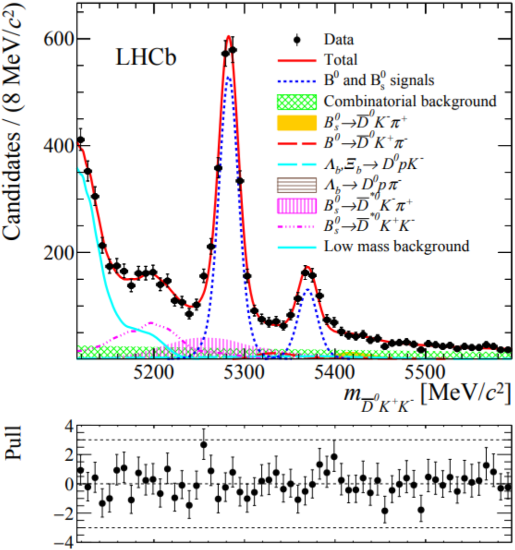
⇛ PID used to discriminate the control channel over signal channel.
⇛ PID selection is optimized.
⇛ The description is very vague in paper. In ANA note: optimized on $\frac{s}{\sqrt{s+b}}$ on NONresampled MC.
⇛ They found that the optimum point is very shallow so it might be ok.



Backgrounds

$\Rrightarrow$ Some can be defeted with PID cuts.
$\Rrightarrow$ Other remain in the fit.
$\Rrightarrow$ They used KDE on MC samples.
$\Rrightarrow$ The most dangerous one is fitted on data using correct mass hypothesis to get the yield.
$\Rrightarrow$ One problem that is observed is the $B_s^0 \to D^* K^- \pi^+$: They expected 540 events however the fit resulted in -2167 ± 1514 events. They assign a systematic.

Observation



Normalization

The ratios of branching fractions are calculated as

$$\frac{\mathcal{B}\left(B^0 \to \overline{D}^0 K^+ K^-\right)}{\mathcal{B}\left(B^0 \to \overline{D}^0 \pi^+ \pi^-\right)} = \frac{N_{B^0 \to \overline{D}^0 K^+ K^-}}{N_{B^0 \to \overline{D}^0 \pi^+ \pi^-}} \times \frac{\varepsilon_{B^0 \to \overline{D}^0 \pi^+ \pi^-}}{\varepsilon_{B^0 \to \overline{D}^0 K^+ K^-}}, \quad (5)$$

and

$$\frac{\mathcal{B}\left(B_s^0 \to \overline{D}^0 K^+ K^-\right)}{\mathcal{B}\left(B^0 \to \overline{D}^0 K^+ K^-\right)} = r_{B_s^0/B^0} \times \frac{\varepsilon_{B^0 \to \overline{D}^0 K^+ K^-}}{\varepsilon_{B_s^0 \to \overline{D}^0 K^+ K^-}} \times \frac{1}{f_s/f_d}, \quad (6)$$

Efficiency

	$B^0 \to \overline{D}^0\pi^+\pi^-$	$B^0 \to \overline{D}^0K^+K^-$	$B_s^0 \to \overline{D}^0K^+K^-$
$\varepsilon^{\text{geom}}$ [%]	15.8 ± 0.0	17.0 ± 0.0	16.9 ± 0.0
$\varepsilon^{\text{sel} \mid \text{geom}}$ [%]	1.2 ± 0.0	1.1 ± 0.0	1.1 ± 0.0
$\varepsilon^{\text{PID} \mid \text{sel \& geom}}$ [%]	95.5 ± 1.2	75.7 ± 1.4	76.3 ± 2.0
ε^{TIS} [%]	42.2 ± 0.7	42.2 ± 0.7	42.2 ± 0.7
ε^{TOS} [%]	40.6 ± 0.6	40.3 ± 0.8	40.6 ± 1.2
$\bar{\varepsilon}^{\text{DP}}_{\text{corr.}}$ [%]	85.5 ± 2.9	95.7 ± 4.1	$101.0^{+3.2}_{-7.1}$
$\varepsilon^{\text{tot},TIS}$ $[10^{-4}]$	6.4 ± 0.2	5.9 ± 0.3	$6.0^{+0.3}_{-0.5}$
$\varepsilon^{\text{tot},TOS}$ $[10^{-4}]$	6.1 ± 0.2	5.7 ± 0.3	$5.8^{+0.3}_{-0.5}$
$\varepsilon^{\text{tot}}[10^{-4}]$	10.6 ± 0.3	9.8 ± 0.4	$10.1^{+0.4}_{-0.6}$

Systematics

Table 4: Summary of relative (in %) systematic uncertainties on yields $N_{B^0\to\bar{D}^0\pi^+\pi^-}$, $N_{B^0\to\bar{D}^0K^+K^-}$ and ratio $r_{B_s^0/B^0}$, due to the PDFs modelling in the $m_{\bar{D}^0\pi^+\pi^-}$ and $m_{\bar{D}^0K^+K^-}$ fits. The uncertainties are uncorrelated and summed in quadrature.

Source	$N_{B^0\to\bar{D}^0\pi^+\pi^-}$	$N_{B^0\to\bar{D}^0K^+K^-}$	$r_{B_s^0/B^0}$
$B^0_{(s)}\to\bar{D}^0h^+h^-$ signal PDF	1.0	2.1	4.2
$B^0\to\bar{D}^{*0}[\bar{D}^0\gamma]\pi^+\pi^-$	1.6	–	–
$B^0\to\bar{D}^0K^+\pi^-$	0.3	–	–
$B_s^0\to\bar{D}^{*0}K^-\pi^+$	0.4	1.4	0.4
$B_s^0\to\bar{D}^{*0}K^+K^-$	–	0.5	1.3
Smearing & shifting	0.5	0.1	0.9
Total	2.0	2.6	4.5
Total on $N_{\text{sig}}/N_{\text{control}}$	3.2		4.5

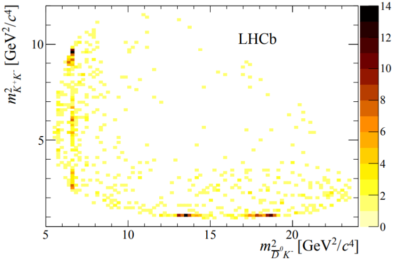
Results

$$\Rightarrow \frac{\mathcal{B}(B^0 \to \bar{D}^0 K^+ K^-}{B^0 \to \bar{D}^0 \pi^+ \pi^-} = (6.9 \pm 0.4 \pm 0.3)\ \%$$

$$\Rightarrow \frac{\mathcal{B}(B_s^0 \to \bar{D}^0 K^+ K^-}{B^0 \to \bar{D}^0 K^+ K^-} = (94.1 \pm 8.9 \pm 8.5)\ \%$$

$$\Rightarrow \mathcal{B}(B^0 \to \bar{D}^0 K^+ K^- = (6.1 \pm 0.4 \pm 0.3 \pm 0.3) \times 10^{-5}$$

$$\Rightarrow \mathcal{B}(B_s^0 \to \bar{D}^0 K^+ K^- = (5.7 \pm 0.5 \pm 0.5 \pm 0.5) \times 10^{-5}$$



Backup