Anatomy of the decay $B^0 \to K^0_S \pi^+ \pi^-$ and first observation of the CP asymmetry in the transition $\bar{B}^0 \to K^{*-} \pi^+$

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Yellow pages

⇛ Proponents: M. Baalouch, E. Ben-Haim, E. Cogneras, T. Gershon, M. Grabalosa, L. Henry, T. Latham, J.M. Maratas, J. McCarthy, D. Milanes, S. Monteil, R. Silva Coutinho, N. Watson

⇛ Reviewers: Stephanie Hansmann-Menzemer (chair), Stefano Gallorini

⇛ EB: Mitesh Patel

⇛ EB readers: Patrick Koppenburg, Simon Eidelman

⇛ Twiki: `https://twiki.cern.ch/twiki/bin/viewauth/LHCbPhysics/Dalitz_KSPiPi`

⇛ Jurnal: PRL.

⇛ Deadline for comments: 13^{th} October.

⇛ Please send me comments before: 12^{th} October.

Physics in the paper

⇛ Looking for new source of CP violation outside the CKM matrix.

⇛ Looking at the transition $b \to s q\bar{q}$, where $q = u, d, s$.

⇛ Rule of thumb: CP violation should be similar to the ones in $b \to s c\bar{c}$.

⇛ The decay $B^0 \to K^0_S \pi^+ \pi^-$ has reach resonant structure!!

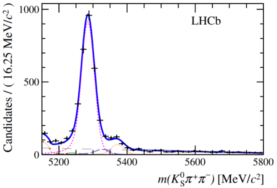


Figure 1: Invariant mass distributions of $K^0_S\pi^+\pi^-$ candidate events, summing the two years of data taking and the two K^0_S reconstruction categories. Data are the black points with error bars and the total fit model is overlaid (solid blue line). The B^0 (B^0_s) signal components are the pink (light blue) short-dashed (dotted) lines, while $K^0_S K^\pm \pi^\mp$ cross-feed contribution for B^0_s (B^0) are the dark blue (green) dashed lines close to the B^0_s (B^0) peak. The sum of the partially reconstructed contributions from B to open charm decays, charmless hadronic decays, $B^0 \to \eta' K^0_S$ and charmless radiative decays are the red dash triple-dotted lines. The combinatorial background contribution is the gray long-dash dotted line.

⇛ Dalitz analysis.

⇛ Because of available statistics, the analysis is untagged and time integrated (isobar model):

$$P(s_+, s_-) = \frac{|A(s_+, s_-)|^2 |\bar{A}(s_+, s_-)|^2}{\int \int_\Omega (|A(s_+, s_-)|^2 |\bar{A}(s_+, s_-)|^2) ds_+ ds_-}$$

Physics in the paper

$\Rrightarrow$ The amplitudes are defined:

$$A = \sum_{j=1}^{N} c_j F_j(s_+, s_-), \quad \bar{A} = \sum_{j=1}^{N} \bar{c}_j \bar{F}_j(s_+, s_-)$$

Resonance	Parameters	Line-shape	Value references
$K^{*\pm}(892)$	$m_0 = 891.66 \pm 0.26$ $\Gamma_0 = 50.8 \pm 0.9$	RBW	[27]
$(K\pi)_0^{*\pm}$	$\mathrm{Re}(c_0) = 0.204 \pm 0.103$ $\Im(c_0) = 0$ $\mathrm{Re}(c_1) = 1$ $\Im(c_1) = 0$	EFKLLM	[28]
$K_2^{*\pm}(1430)$	$m_0 = 1425.6 \pm 1.5$ $\Gamma_0 = 98.5 \pm 2.7$	RBW	[27]
$K^{*\pm}(1680)$	$m_0 = 1717 \pm 27$ $\Gamma_0 = 332 \pm 110$	Flatté [29]	[27]
$f_0(500)$	$\mathrm{m}_0 = 513 \pm 32$ $\Gamma_0 = 335 \pm 67$	RBW	[30]
$\rho^0(770)$	$m_0 = 775.26 \pm 0.25$ $\Gamma_0 = 149.8 \pm 0.8$	GS [31]	[27]
$f_0(980)$	$m_0 = 965 \pm 10$ $g_\pi = 165 \pm 18$ $g_K = 695 \pm 93$	Flatté	[32]
$f_0(1500)$	$m_0 = 1505 \pm 6$ $\Gamma_0 = 109 \pm 7$	RBW	[27]
χ_{c0}	$m_0 = 3414.75 \pm 0.31$ $\Gamma_0 = 10.5 \pm 0.6$	RBW	[27]
Non-resonant (NR)		phase space	

$$A_{CP} = \frac{|\bar{c}_j|^2 - |c_j|^2}{|\bar{c}_j|^2 + |c_j|^2}$$

Experimental elements

⇛ Run1 data set! (3 fb^{-1}).

⇛ Interesting trigger solution:

- $K_S^0 \to \pi\pi$ can decay outside the VELO.
- Only for the second part of 2012 (1.4 fb^{-1}) there was an HLT2 line implemented which considered downstream K_S^0.

⇛ BDT for selection.

⇛ Correcting efficiency in Dalitz plane.

Results

$\Rightarrow$ Paper reports:

$$\mathcal{F}_j = \frac{\int\int_\Omega |c_j F_j(s_+, s_-)|^2 ds_+ ds_-}{\int\int_\Omega |\sum_j c_j F_j(s_+, s_-)|^2 ds_+ ds_-}$$

$$A_{CP} = \frac{|\bar{c}_j|^2 - |c_j|^2}{|\bar{c}_j|^2 + |c_j|^2}$$

Results

$\Rightarrow$ Paper reports:

$$
\begin{aligned}
\mathcal{F}(K^{*\pm}(892)\pi^{\mp}) &= 9.43 \pm 0.40 \pm 0.33 \pm 0.34\,,\\
\mathcal{F}((K\pi)_0^{*\pm}\pi^{\mp}) &= 32.7 \pm 1.4 \pm 1.5 \pm 1.1\,,\\
\mathcal{F}(K_2^{*\pm}(1430)\pi^{\mp}) &= 2.45\,^{+\,0.10}_{-\,0.08} \pm 0.14 \pm 0.12\,,\\
\mathcal{F}(K^{*\pm}(1680)\pi^{\mp}) &= 7.34 \pm 0.30 \pm 0.31 \pm 0.06\,,\\
\mathcal{F}(f_0(980)K_S^0) &= 18.6 \pm 0.8 \pm 0.7 \pm 1.1\,,\\
\mathcal{F}(\rho^0(770)K_S^0) &= 3.8\,^{+\,1.1}_{-\,1.6} \pm 0.7 \pm 0.4\,,\\
\mathcal{F}(f_0(500)K_S^0) &= 0.32\,^{+\,0.40}_{-\,0.08} \pm 0.19 \pm 0.23\,,\\
\mathcal{F}(f_0(1500)K_S^0) &= 2.60 \pm 0.54 \pm 1.28 \pm 0.60\,,\\
\mathcal{F}(\chi_{c0}K_S^0) &= 2.23\,^{+\,0.40}_{-\,0.32} \pm 0.22 \pm 0.13\,,\\
\mathcal{F}(K_S^0\pi^+\pi^-)^{\mathrm{NR}} &= 24.3 \pm 1.3 \pm 3.7 \pm 4.5
\end{aligned}
$$

Results

⇛ Paper reports:

$$
\begin{aligned}
\mathcal{A}_{CP}(K^{*\pm}(892)\pi^{\mp}) &= -0.308 \pm 0.060 \pm 0.011 \pm 0.012\,,\\
\mathcal{A}_{CP}((K\pi)_0^{*\pm}\pi^{\mp}) &= -0.032 \pm 0.047 \pm 0.016 \pm 0.027\,,\\
\mathcal{A}_{CP}(K_2^{*\pm}(1430)\pi^{\mp}) &= -0.29 \pm 0.22 \pm 0.09 \pm 0.03\,,\\
\mathcal{A}_{CP}(K^{*\pm}(1680)\pi^{\mp}) &= -0.07 \pm 0.13 \pm 0.02 \pm 0.03\,,\\
\mathcal{A}_{CP}(f_0(980)K_{\mathrm{S}}^0) &= 0.28 \pm 0.27 \pm 0.05 \pm 0.14\,,
\end{aligned}
$$

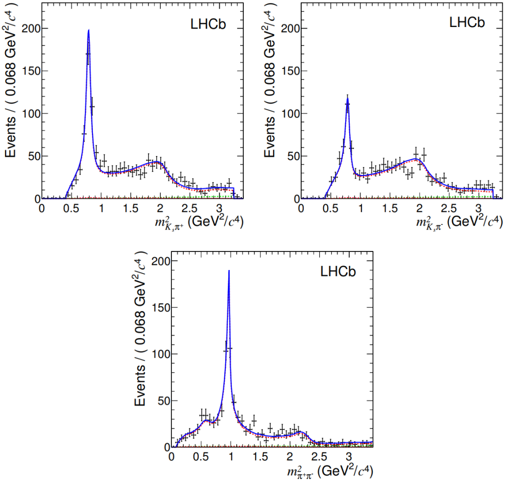
⇛ The result is $6.8(6.0)\,\sigma$ away from being zero. (including systematics).

⇛ Reasonable agreement with world average:

$$A_{CP}(K^{*\pm}\pi^{\mp}) - 0.23 \pm 0.06$$

Results

⇛ Paper reports:



Systematics

⇛ There are two cathegories of systematics:

- Experimental.
- Model related.

⇛ The experimental one were obtained with pseudo experiments.

⇛ Dominant systematics is the efficiency determination!

⇛ Model related systematics are also evaluated:

- Varying each of the parameters of the mean and the width.
- related to marginal $f_2(1270)$ and $f_0(500)$ resonance components.

First comments

$\Rightarrow$ Overall the analysis seems solid!!

$\Rightarrow$ Some things might be better described in the paper.

$\Rightarrow$ Some physics comments:

- Non-resonant modelling.
- Over estimation of model systematic.
-

$\Rightarrow$ Paper is to long: 3803 words (PRL : 3750).

Backup