Searches for $\Lambda^0_b$ and $\Xi^0_b$ decays to $K^0_{S_p}\pi^-$ and $K^0_{S_p}\pi\pi^-$ final states at LHCb


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Charmless three body b-baryon decays

The study of b-baryon decays is still at an early stage (where LHCb has been taking the lead). Among the possible ground states with spin-parity $J^P = \frac{1}{2}^+$, no hadronic three-body decay to a charmless final state had been observed.

- Conservation of baryon number allows $CP$ violation searches without the need to identify the flavour of the initial state.
- Search for direct $CP$ violation in baryonic decays (no mixing).
- Dalitz plot analyses provide more sensitivity to $CP$ violation observables.
- Searches for $\Lambda^0_b$ decays also consider the $\Xi^0_b$ mass region.
Analysis strategy for $\Lambda^0_b(\Xi^0_b)$ decays

Searches for the unobserved decays $\Lambda^0_b(\Xi^0_b) \rightarrow K^0_s p\pi^-$ and $\Lambda^0_b(\Xi^0_b) \rightarrow K^0_s pK^-$ with respect to the $B^0 \rightarrow K^0_s \pi^+\pi^-$ decay (BF measurement), with the data collected by LHCb during 2011 – 1fb$^{-1}$.

- Decays reconstructed in two $K^0_s$ categories – Downstream and Long Tracks.

- Multivariate boosted decision tree and PID selection trained for each $K^0_s$ type, and optimised by (blind analysis):

  \[
  \text{FoM} = \frac{\varepsilon_{\text{sig}}}{(3/2 + \sqrt{B})}
  \]

- Separate charmless decays from those via $\Lambda_c^+ \rightarrow K^0_s p$ and $D^- \rightarrow K^0_s K$.

- Dynamical structure of Dalitz plot is accounted for to correct the non-uniform $\varepsilon_{\text{sig}}$ over the phase space.
$\Lambda^0_b(\Xi^0_b) \rightarrow K^0_{S} p\pi^-$ results

$B(\Lambda^0_b \rightarrow K^0_{S} p\pi^-) = (1.26 \pm 0.19 \pm 0.09 \pm 0.34 \pm 0.05) \times 10^{-5}$

$B(\Lambda^0_b \rightarrow K^0_{S} pK^-) < 3.5 \ (4.0) \times 10^{-6}$ at 90% (95%) CL

$\Lambda^0_b(\Xi^0_b)$ decays to $\Lambda^0_c h^-$ and $D^-_s p$ final states

$$B(\Lambda^0_b \to \Lambda^+_c \pi^-) = (5.97 \pm 0.28 \pm 0.34 \pm 0.70 \pm 0.24) \times 10^{-3}$$

$$B(\Lambda^0_b \to D^-_s p) < 4.8 \times 10^{-4} \text{ at } 90\% \text{ CL}$$

$$B(\Lambda^0_b \to \Lambda^+_c K^-) = (3.55 \pm 0.44 \pm 0.24 \pm 0.41 \pm 0.14) \times 10^{-4}$$

$\Lambda^0_b \to D^-_s [K^0_S K^-]p$
\[ \Lambda^0_{b} \rightarrow K^0_S p \pi^- \ A^{CP} \ measurement \]

The significant signal observed for the \( \Lambda^0_{b} \rightarrow K_S p \pi^- \) channel allows a measurement of its phase-space integrated \( CP \) asymmetry, which may be determined from the raw asymmetry:

\[
A_{CP}^{RAW} = \frac{N_{\bar{f}} - N_f}{N_{\bar{f}} + N_f}
\]

where \( A_{CP} = A_{CP}^{RAW} - A_P - A_D \)

Detection and production asymmetries can be conveniently cancelled with \( \Lambda^0_{b} \rightarrow \Lambda^+_c (K^0_S p) \pi^- \) decays (in which the expected \( CP \) violation is negligible).

The inclusive raw asymmetries are found to be:

\[ A_{CP}^{RAW}(\Lambda^0_{b} \rightarrow \Lambda^+_c (K^0_S p) \pi^-) = -0.05 \pm 0.03 \]
\[ A_{CP}^{RAW}(\Lambda^0_{b} \rightarrow K^0_S p \pi^-) = 0.17 \pm 0.13 \]

Finally, the \( CP \) asymmetry is measured to be:

\[ A_{CP}(\Lambda^0_{b} \rightarrow K^0_S p \pi^-) = 0.22 \pm 0.13 \text{(stat.)} \pm 0.03 \text{(syst.)} \]

A future update of this analysis with 2012 (2 fb\(^{-1}\)) data has a clear appeal!

A first inspection of the distribution of \( \Lambda^0_{b} \rightarrow K^0_S p \pi^- \) decays across the phase space shows that an amplitude analysis is an exciting future prospect!
Thank you for your attention.


“Searches for $\Lambda_{b}^{0}$ and $\Xi_{b}^{0}$ decays to $K_{S}^{0}\rho\pi^{-}$ and $K_{S}^{0}\rho K^{-}$ final states with first observation of the $\Lambda_{b}^{0} \rightarrow K_{S}^{0}\rho\pi^{-}$ decay”