SEARCHES FOR Λ_b^0 AND Ξ_b^0 DECAYS TO $K_S^0 p\pi^-$ AND $K_S^0 pK^-$ FINAL STATES WITH FIRST OBSERVATION OF THE $\Lambda_b^0 \to K_S^0 p\pi^-$ DECAY

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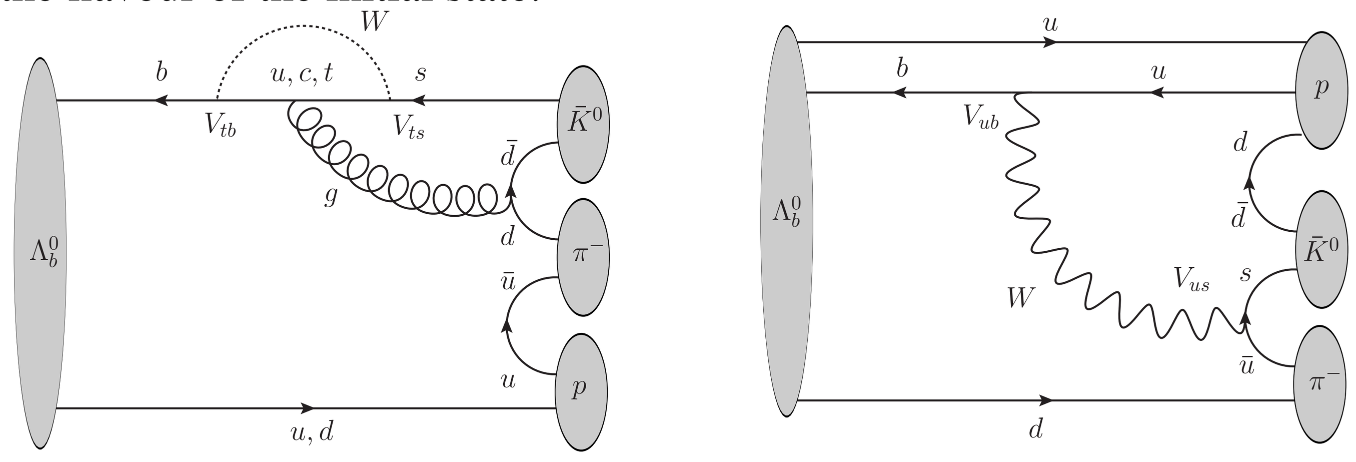
PHYSICS MOTIVATION

The study of beauty baryon decays is still at an early stage. Among the possible ground states with spin-parity $J^P = \frac{1}{2}^+$ [1], no hadronic three-body decay to a charmless final state had been observed. These channels provide many interesting characteristics:

- Conservation of baryon number allows CP violation searches without the need to identify the flavour of the initial state.

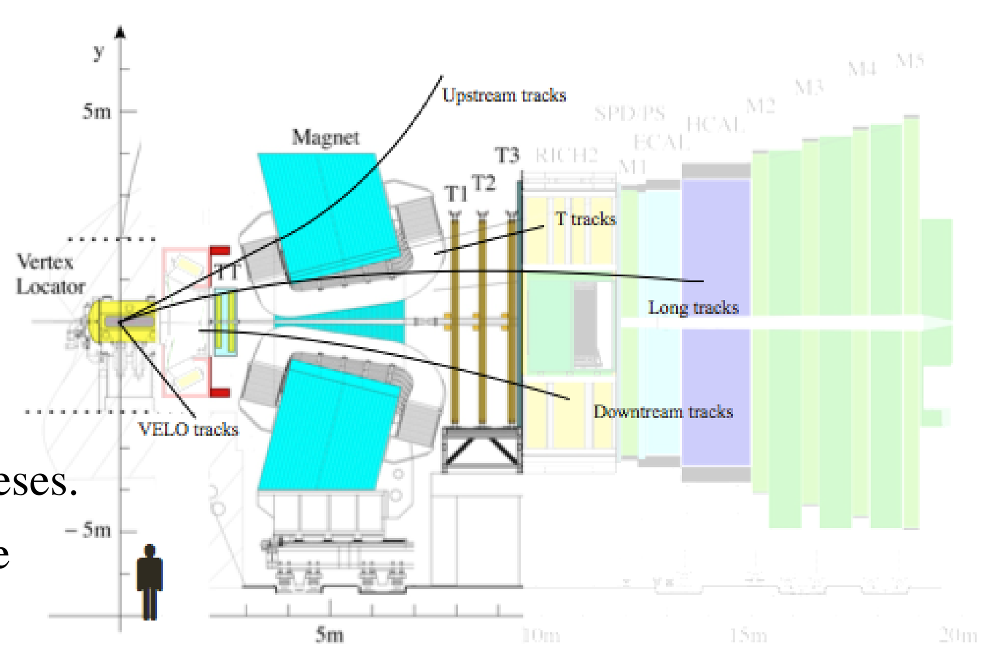


- Dalitz plot analyses provide more sensitivity to CP violation observables.
- Further investigate QCD effects such as the observation that the Λ_b^0 is produced unpolarised in proton-proton collisions [2].

EVENT SELECTION

The analysis is performed with an integrated luminosity of $1.0\ \mathrm{fb}^{-1}$, from the 7 TeV centre-of-mass pp collision dataset, collected with the LHCb detector during 2011 [3].

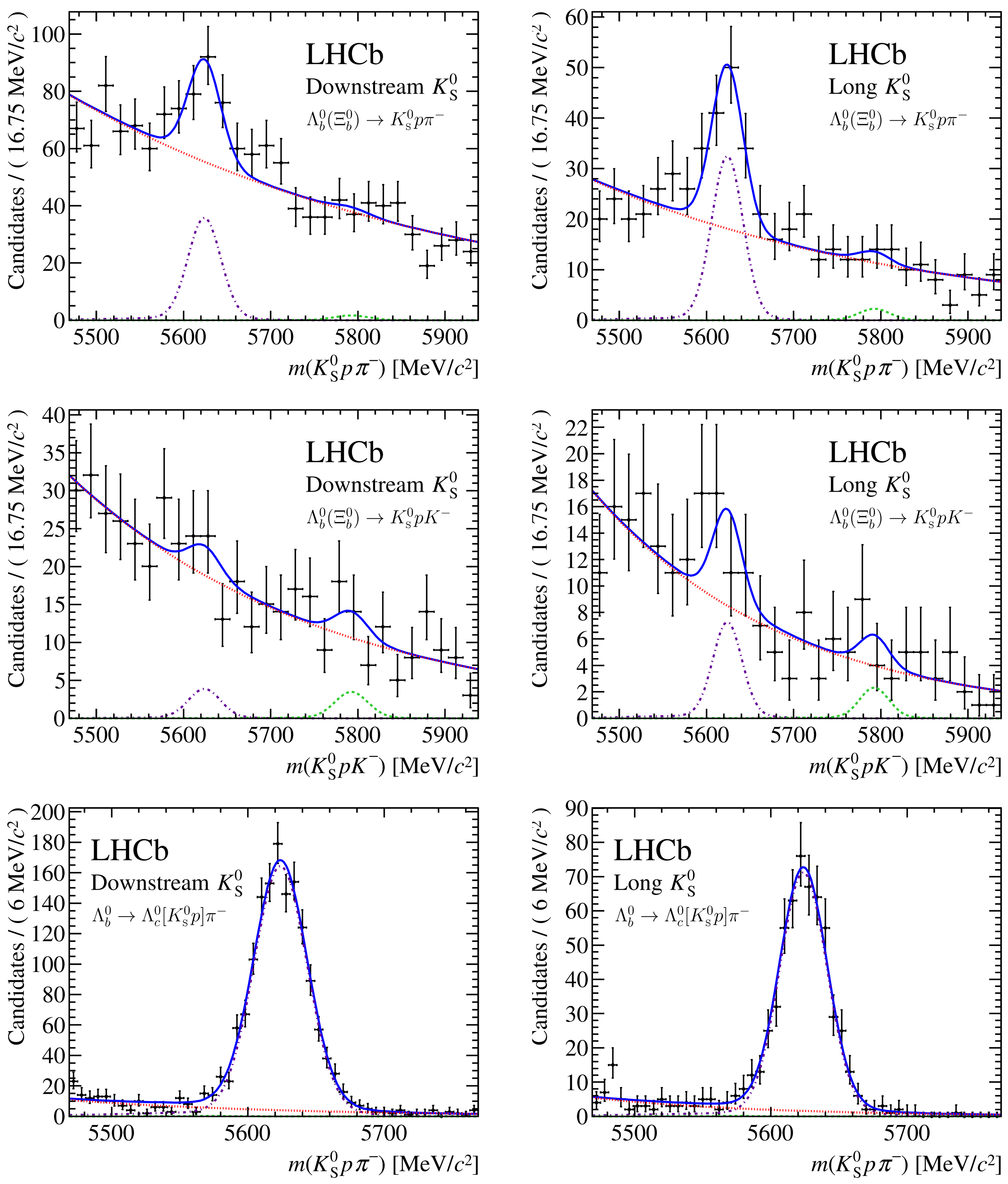
- Decays reconstructed with two K_S^0 categories – Downstream and Long tracks.
- Multivariate boosted decision tree selection trained separately for each K_S^0 type [4], and optimised based on $\mathrm{FoM} = \epsilon_{\mathrm{sig}}/(3/2 + \sqrt{\mathrm{B}})$ [5].
- Further particle identification requirements for the different hypotheses.
- Separate charmless decays from those via $\Lambda_c^+ \to K_S^0 p$ and $D_s^- \to K_S^0 K^-$.

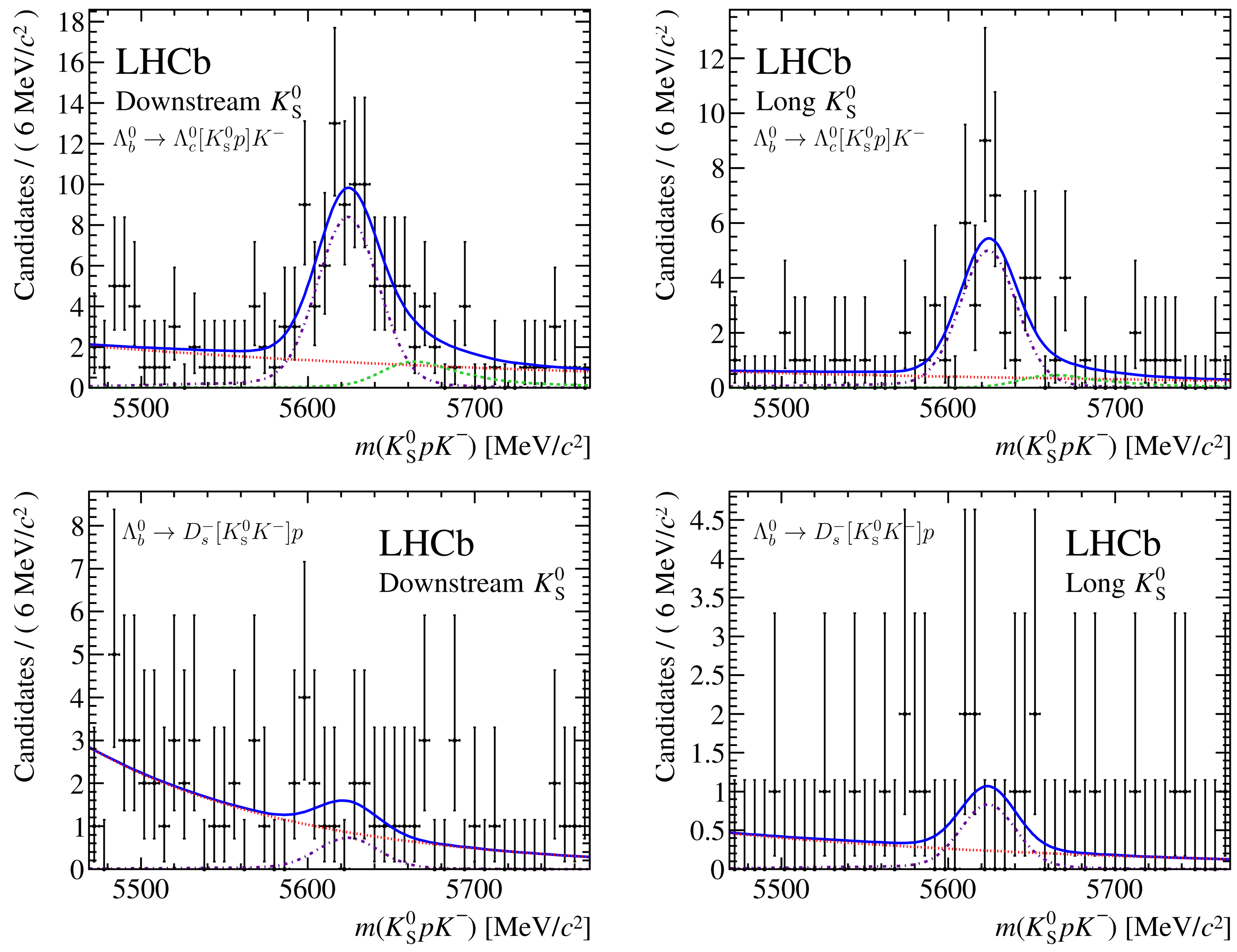


FIT MODEL AND RESULTS

A simultaneous unbinned extended maximum likelihood fit to the invariant mass distributions of all decay channels is performed.

- Sum of a core Gaussian and a bifurcated Gaussian to describe the signal, plus background components (mis-ID, partially-reconstructed and combinatorial) are considered.





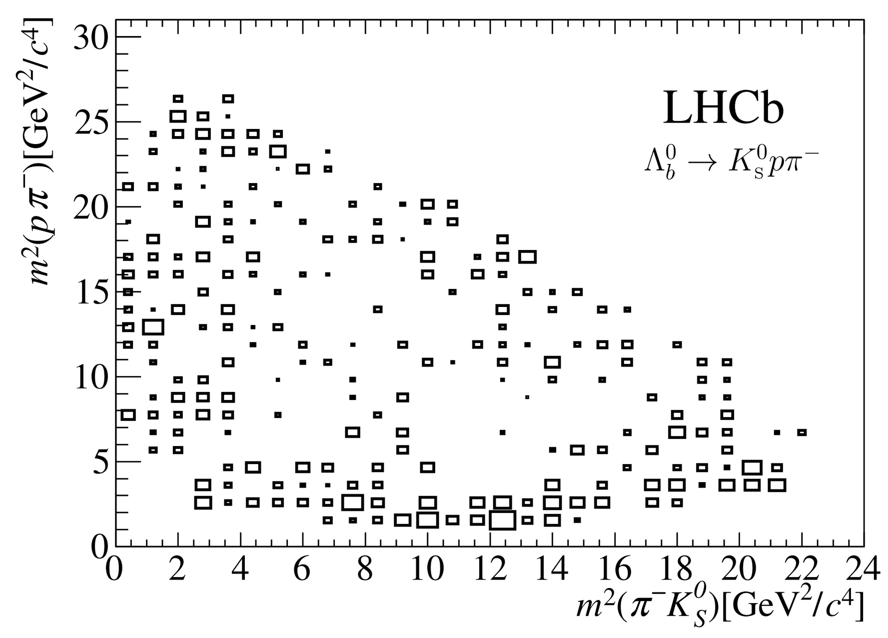
RESULTS

✓ **Branching fraction measurements**

The measurements of the branching fractions of the $\Lambda_b^0(\Xi_b^0) \to K_S^0 ph^-$ decays ($h = \pi, K$) are performed relative to the well established $B^0 \to K_S^0\pi^+\pi^-$ decay mode, according to :

$$\frac{\mathcal{B}(\Lambda_b^0(\Xi_b^0) \to K_S^0 ph^-)}{\mathcal{B}(B^0 \to K_S^0\pi^\pm\pi^\mp)} = \frac{\epsilon^{\mathrm{sel.}}_{B^0\to K_S^0\pi^\pm\pi^\mp}}{\epsilon^{\mathrm{sel.}}_{\Lambda_b^0(\Xi_b^0)\to K_S^0 ph^-}} \frac{\epsilon^{\mathrm{PID}}_{B^0\to K_S^0\pi^\pm\pi^\mp}}{\epsilon^{\mathrm{PID}}_{\Lambda_b^0(\Xi_b^0)\to K_S^0 ph^-}} \frac{N_{\Lambda_b^0(\Xi_b^0)\to K_S^0 ph^-}}{N_{B_d^0\to K_S^0\pi^\pm\pi^\mp}} \frac{f_d}{f_{\Lambda_b^0(\Xi_b^0)}}$$

The dynamical structure described by the Dalitz plot must be accounted for to correct for the non-flat efficiencies over the phase space. An example shown here is for the $\Lambda_b^0 \to K_S^0 p\pi^-$ decay



Using the world average of $\mathcal{B}(B_d^0 \to K^0\pi^+\pi^-) = (4.96 \pm 0.20) \times 10^{-5}$, the branching fractions are determined to be

$$\begin{aligned}
\mathcal{B}(\Lambda_b^0 \to \overline{K}^0 p\pi^-) &= (1.26 \pm 0.19 \pm 0.09 \pm 0.34 \pm 0.05) \times 10^{-5}\,,\\
\mathcal{B}(\Lambda_b^0 \to K^0 pK^-) &< 3.5\ (4.0) \times 10^{-6} \ \text{ at } \ 90\,\%\ (95\,\%)\ \mathrm{CL}\,,\\
f_{\Xi_b^0}/f_d \times \mathcal{B}(\Xi_b^0 \to \overline{K}^0 p\pi^-) &< 1.6\ (1.8) \times 10^{-6} \ \text{ at } \ 90\,\%\ (95\,\%)\ \mathrm{CL}\,,\\
f_{\Xi_b^0}/f_d \times \mathcal{B}(\Xi_b^0 \to \overline{K}^0 pK^-) &< 1.1\ (1.2) \times 10^{-6} \ \text{ at } \ 90\,\%\ (95\,\%)\ \mathrm{CL}\,,\\
\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+\pi^-) &= (5.97 \pm 0.28 \pm 0.34 \pm 0.70 \pm 0.24) \times 10^{-3}\,,\\
\mathcal{B}(\Lambda_b^0 \to \Lambda_c^+ K^-) &= (3.55 \pm 0.44 \pm 0.24 \pm 0.41 \pm 0.14) \times 10^{-4}\,.\\
\mathcal{B}(\Lambda_b^0 \to D_s^- p) &< 4.8\ (5.3) \times 10^{-4} \ \text{ at } \ 90\,\%\ (95\,\%)\ \mathrm{CL}\,.
\end{aligned}$$

✓ **Direct CP asymmetry**

The significant signal observed for the $\Lambda_b^0 \to K_S^0 p\pi^-$ channel allows a measurement of its direct CP asymmetry. Correcting possible production and detection asymmetries using the $\Lambda_b^0 \to \Lambda_c^+\pi^-$ decay mode (in which the $\mathcal{A}^{CP}$ is expected to be zero), the phase-space integrated asymmetry is found to be

$$\mathcal{A}^{CP}(\Lambda_b^0 \to K_S^0 p\pi^-) = 0.22 \pm 0.13\,(\mathrm{stat}) \pm 0.03\,(\mathrm{syst})\,,$$

which is consistent with zero.

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