The study of beauty baryon decays is still at an early stage. Among the possible ground states with spin-parity $J^P = \frac{3}{2}^-$ [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 $L_b^0$ is produced unpolarised in proton-proton collisions [2].

### Event Selection

The analysis is performed with an integrated luminosity of 1.0 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 FoM = $n_{c0}/(3/2 + \sqrt{5})$ [5].
- Further particle identification requirements for the different hypotheses.
- Separate charmless decays from those via $\Lambda_b^0 \to K^0_s p$ and $D^- \to K^0_s K$.

### 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 $\Lambda_b^0 \to K^0_s \pi^- \pi^-$ decays ($b = K, \pi$) are performed relative to the well established $B^0 \to K^0_S \pi^- \pi^-$ decay mode, according to:

$$B(\Lambda_b^0 \to K^0_s \pi^- \pi^-) = \frac{\rho_{b} f_{\pi^-} f_{\pi^-}}{\rho_{K} f_{\pi^-} f_{\pi^-}} B(B^0 \to K^0_S \pi^- \pi^-) \times \frac{N(\Lambda_b^0 \to K^0_s \pi^- \pi^-)}{N(B^0 \to K^0_S \pi^- \pi^-)} \times f_{\Lambda_b^0}$$

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 $\Lambda_b^0 \to K^0_s \pi^- \pi^-$ decay

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

- $B(\Lambda_b^0 \to K^0_s \pi^- \pi^-) = (1.26 \pm 0.19 \pm 0.09 \pm 0.34 \pm 0.05) \times 10^{-5}$,
- $B(\Lambda_b^0 \to K^0_s p \pi^-) < 3.5 \times 10^{-5}$ at 90\% (95\%) CL,
- $f_{\rho_b} / f_{\rho_K} \times B(\Lambda_b^0 \to K^0_s \pi^- \pi^-) < 1.6 \times 10^{-5}$ at 90\% (95\%) CL,
- $f_{\rho_b} / f_{\rho_K} \times B(\Lambda_b^0 \to K^0_s p \pi^-) < 1.1 \times 10^{-5}$ at 90\% (95\%) CL,
- $B(\Lambda_b^0 \to \Lambda^- \pi^+) = (5.97 \pm 0.28 \pm 0.34 \pm 0.70 \pm 0.24) \times 10^{-3}$,
- $B(\Lambda_b^0 \to \Lambda^- \pi^-) = (3.55 \pm 0.44 \pm 0.24 \pm 0.41 \pm 0.14) \times 10^{-3}$,
- $B(\Lambda_b^0 \to D^- \pi^-) < 4.8 \times 10^{-3}$ at 90\% (95\%) CL.

**Direct $CP$ asymmetry**

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

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

which is consistent with zero.

### Bibliography