Using $\Lambda_b \to \Lambda\mu^+\mu^-$ data within a Bayesian analysis of $|\Delta B| = |\Delta S| = 1$ decays[†]

S. Meinel[*1,*2] and D. van Dyk[*3]

The tensions between theory and experiment for P_5' [1,2], one of the angular observables in the kinematic distribution of the decay $\bar{B} \to \bar{K}^*(\to \bar{K}\pi)\mu^+\mu^-$, have sparked much interest in the determination of the short-distance couplings in flavor-changing neutral currents of the form $b \to s\ell^+\ell^-$. Several competing global analyses that use the available data on such rare decays of $\bar{B}$ mesons to various degrees find that a negative shift in one of the Wilson coefficients, $\mathcal{C}_9$, improves the agreement with the data[3]. However, it remains unclear whether this effect is caused by physics beyond the Standard Model, or merely by uncontrolled hadronic contributions.

The baryonic rare decay $\Lambda_b \to \Lambda(\to p\pi^-)\mu^+\mu^-$ [4] offers complementary constraints compared to the commonly used mesonic channels. A recent lattice QCD calculation of the relevant $\Lambda_b \to \Lambda$ form factors[5] enables us to evaluate the $\Lambda_b \to \Lambda(\to p\pi^-)\mu^+\mu^-$ observables with high precision. In this work, we studied the constraining power of the b-baryon decay in a global analysis of $|\Delta B| = |\Delta S| = 1$ decays. Our analysis includes the following observables:

- For the baryonic decay $\Lambda_b \to \Lambda(\to p\pi^-)\mu^+\mu^-$ we used the LHCb measurements[4] of the differential branching fraction $\langle\mathcal{B}\rangle_{15,20}$, the fraction of longitudinally polarized dileptons $\langle F_L\rangle_{15,20}$, the lepton-side forward-backward asymmetry $\langle A_{\rm FB}^{\ell}\rangle_{15,20}$, and the hadron-side forward-backward asymmetry $\langle A_{\rm FB}^{\Lambda}\rangle_{15,20}$, all in the bin $15\,\mathrm{GeV}^2 \le q^2 \le 20\,\mathrm{GeV}^2 \simeq q^2_{\max}$.
- For the decay $\bar{B}_s \to \mu^+\mu^-$, we included the time-integrated branching ratio from a combined analysis of the CMS and LHCb collaborations[6].
- We use the Belle[7] and Babar[8] measurements of the branching ratio of the inclusive mode $\bar{B} \to X_s\ell^+\ell^-$ in the bin $1\,\mathrm{GeV}^2 \le q^2 \le 6\,\mathrm{GeV}^2$.

We performed a Bayesian analysis of several scenarios, including the Standard Model (where only nuisance parameters are fitted) and scenarios in which subsets of the Wilson coefficients are allowed to float. The 2D-marginalized posterior for the $\mathcal{C}_9$-$\mathcal{C}_{10}$ scenario is shown in Fig. 1. The best-fit point has $\mathcal{C}_9 - \mathcal{C}_9^{\rm SM} = +1.6^{+0.7}_{-0.9}$, which is opposite in sign compared to the global fits of mesonic-only decays[3]. Furthermore, the posterior odds favor the Standard Model over the scenarios in which Wilson coefficients are allowed to float. The uncertainties in our analysis of $\Lambda_b \to \Lambda(\to p\pi)\ell^+\ell^-$ are currently dominated by experiment, and will be reduced with higher-statistics results and a full angular analysis expected in the near future.

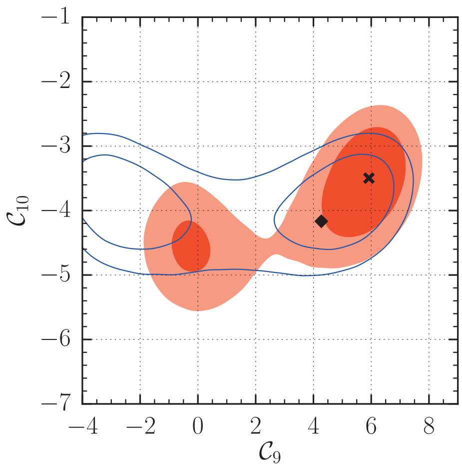

Fig. 1. The 2D-marginalized posterior in the $\mathcal{C}_9$-$\mathcal{C}_{10}$ plane. To demonstrate the impact of the baryonic decay in the analysis, we show the results from a fit to the $\bar{B} \to X_s\ell^+\ell^-$ and $\bar{B}_s \to \mu^+\mu^-$ branching ratios only (blue lines) and from the full fit including also the $\Lambda_b \to \Lambda(\to p\pi^-)\mu^+\mu^-$ observables (orange-red areas). The SM point is marked with a diamond, while the best-fit point from the full fit is marked with a cross.

References
1) R. Aaij *et al.* [LHCb Collaboration], Phys. Rev. Lett. **111**, 191801 (2013).
2) R. Aaij *et al.* [LHCb Collaboration], JHEP **1602**, 104 (2016).
3) T. Blake, G. Lanfranchi, D. M. Straub, Prog. Part. Nucl. Phys. **92**, 50 (2017).
4) R. Aaij *et al.* [LHCb Collaboration], JHEP **1506**, 115 (2015).
5) W. Detmold, S. Meinel, Phys. Rev. D **93**, 074501 (2016).
6) V. Khachatryan *et al.* [CMS and LHCb Collaborations], Nature **522**, 68 (2015).
7) M. Iwasaki *et al.* [Belle Collaboration], Phys. Rev. D **72**, 092005 (2005).
8) J. P. Lees *et al.* [BaBar Collaboration], Phys. Rev. Lett. **112**, 211802 (2014).

† Condensed from the article in Phys. Rev. D **94**, 013007 (2016)

*1 RIKEN Nishina Center
*2 Department of Physics, University of Arizona
*3 Physik-Institut, Universität Zürich