Latest LHCb measurements of semileptonic b-hadron decays

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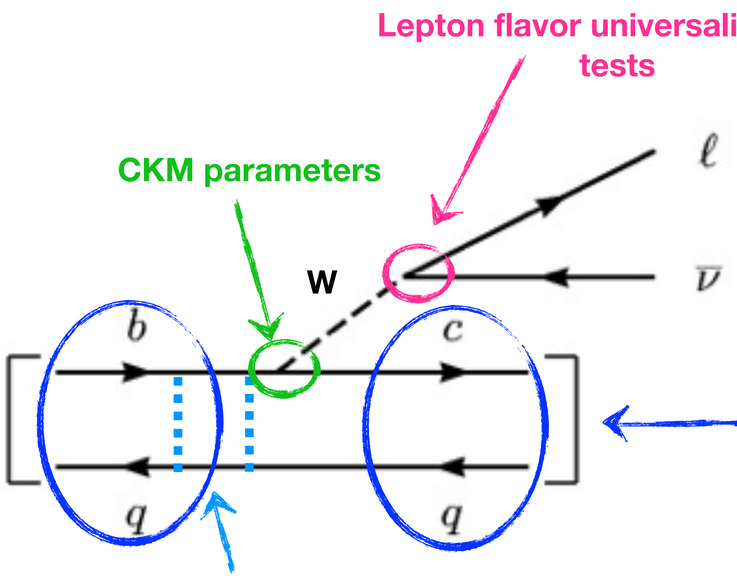
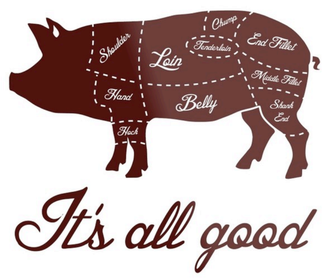
Toronto - August 5 and 6, 2019

Why semileptonic b-hadron decays ?

- Good probes for lots of studies:

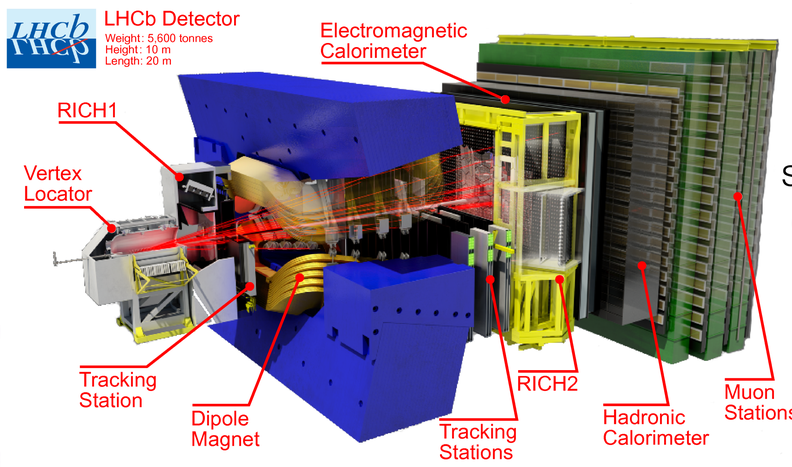




b- and c-hadron properties: production fractions, form factors, lifetimes

- High branching fractions $\mathfrak{B}(B \to Xl\nu) \sim 10\%$
- **Theoretically *clean*:** only b → c current, parametrized in terms of scalar functions
- **Theoretical uncertainty *under control:*** could be further reduced with improvements in lattice QCD calculations
- ~~**Fully**~~ **reconstructed** signal due to missing neutrinos

The LHCb detector @ the LHC



LHCb is a forward spectrometer ($2 < \eta < 5$) designed for ***B*** physics with *proton-proton* collisions

~100 M semileptonic decays of b-hadrons (B, B_s, B_c, Λ_b, …) collected

Λ_c^+, Ξ_c^+, Ξ_c^0 baryon lifetimes [1]

- In Heavy Quark Effective Theory (HQET), at lowest order (LO), all charm lifetimes are equal. Sizable corrections enter at $O(1/m_c^2, 1/m_c^3)$ → charm hadron lifetimes provide a sensitive probe of these higher order (HO) corrections
- **Results:**

$$\tau_{\Lambda_c^+} = 203.5 \pm 1.0 \pm 1.3 \pm 1.4 \text{ fs}$$
$$\tau_{\Xi_c^+} = 456.8 \pm 3.5 \pm 2.9 \pm 3.1 \text{ fs}$$
$$\tau_{\Xi_c^0} = 154.5 \pm 1.7 \pm 1.6 \pm 1.0 \text{ fs}$$

stat. **syst.** **due to the uncertainty in the D^+ lifetime**

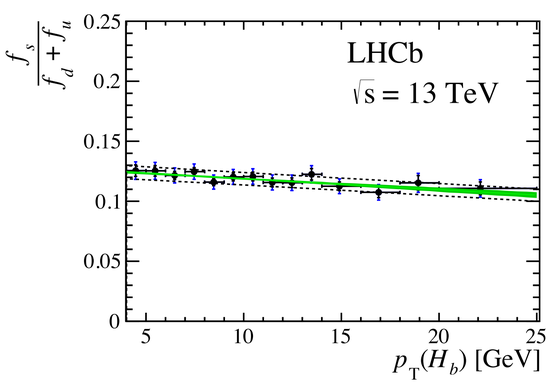
- The measurements are 3-4 times more precise than the current world average. Λ_c^+, Ξ_c^+ lifetimes consistent with the world averages whilst Ξ_c^0 one is ~3.3σ higher

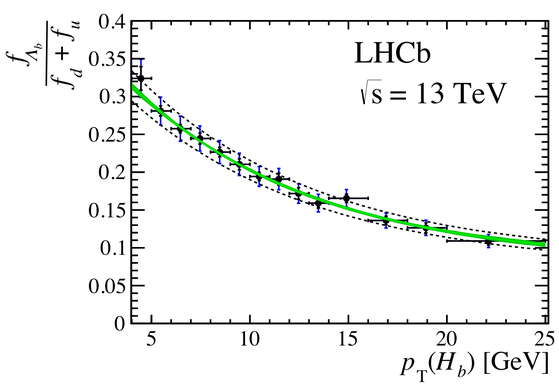
$\bar{B}_s^0$, Λ_b^0 fragmentation fractions [2]

- Knowledge of the fragmentation fractions of $\bar{B}_s^0$ (f_s) and Λ_b^0 ($f_{\Lambda b0}$) hadrons is essential for determining absolute branching fractions of decays of these hadrons at the LHC
  → measurement of $\mathfrak{B}(\bar{B}_s^0 \to \mu^-\mu^+)$ and evaluation of $|V_{cb}|$ from $\Lambda_b^0 \to \Lambda_c^+ \mu^- \bar{\nu}_\mu$ decays
- The measured fractions of $\bar{B}_s^0$ and Λ_b^0 are normalized to the sum of B^- and $\bar{B}^0$ fractions:

$$\frac{f_s}{f_u + f_d} = 0.122 \pm 0.006 \qquad \frac{f_{\Lambda_b^0}}{f_u + f_d} = 0.259 \pm 0.018$$

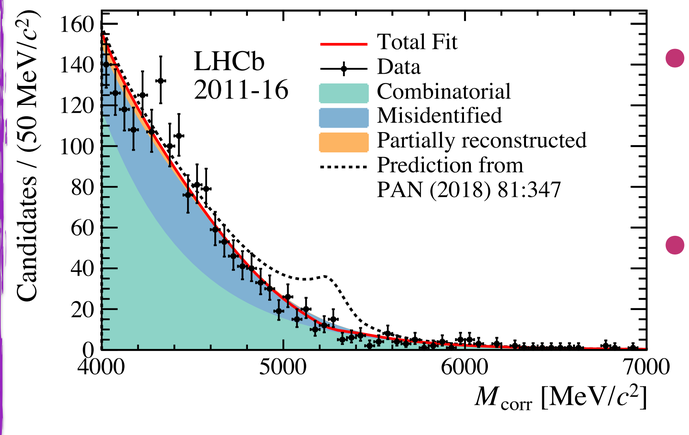
- The Λ_b^0 ratio depends strongly on transverse momentum, while the $\bar{B}_s^0$ ratio shows a mild dependence





Search for $B^+ \to \mu^+\mu^-\mu^+\nu_\mu$ [3]

- Fully l*eptonic* B^+ decays are rare as their branching fraction is proportional to $|V_{ub}|^2$. $B^+ \to l^+\nu_l$ decays have precise Standard Model predictions and are *helicity* suppressed
  → highly sensitive to New Physics
- At LHCb, measuring $B^+ \to \mu^+\nu_\mu$ decays is challenging. This problem is absent for the $B^+ \to \mu^+\mu^-\mu^+\nu_\mu$ decay which receives contributions from $B^+ \to \mu^+\nu_\mu\gamma^*$ and $B^+ \to \mu^+\nu_\mu V$ (where V is a vector-meson such as ω and ρ)



- Data compared with recent theoretical prediction [4] (vector-meson dominance)
- An **upper limit** on $\mathfrak{B}$ is set: 1.4×10^{-8} at 95% C.L.

References

[1] = LHCb collaboration, *Precision measurement of the Λ_c^+, Ξ_c^+, Ξ_c^0 baryon lifetimes* [Phys. Rev. D 100, 032001]

[2] = LHCb collaboration, *Measurement of b-hadron fractions in 13 TeV pp collisions* [LHCb-PAPER-2018-050, arXiv:1902.06794]

[3] = LHCb collaboration, *Search for the rare decay $B^+ \to \mu^+\mu^-\mu^+\nu_\mu$* [LHCb-PAPER-2018-037, arXiv:1812.06004]

[4] = A. V. Danilina and N. V. Nikitin, *Four-Leptonic Decays of Charged and Neutral B Mesons within the Standard Model* [Phys. Atom. Nucl. 81 (2018) 347]