Semileptonic B decays at LHCb

Matthew Rudolph
Syracuse University

on behalf of the LHCb Collaboration

August 3, 2017

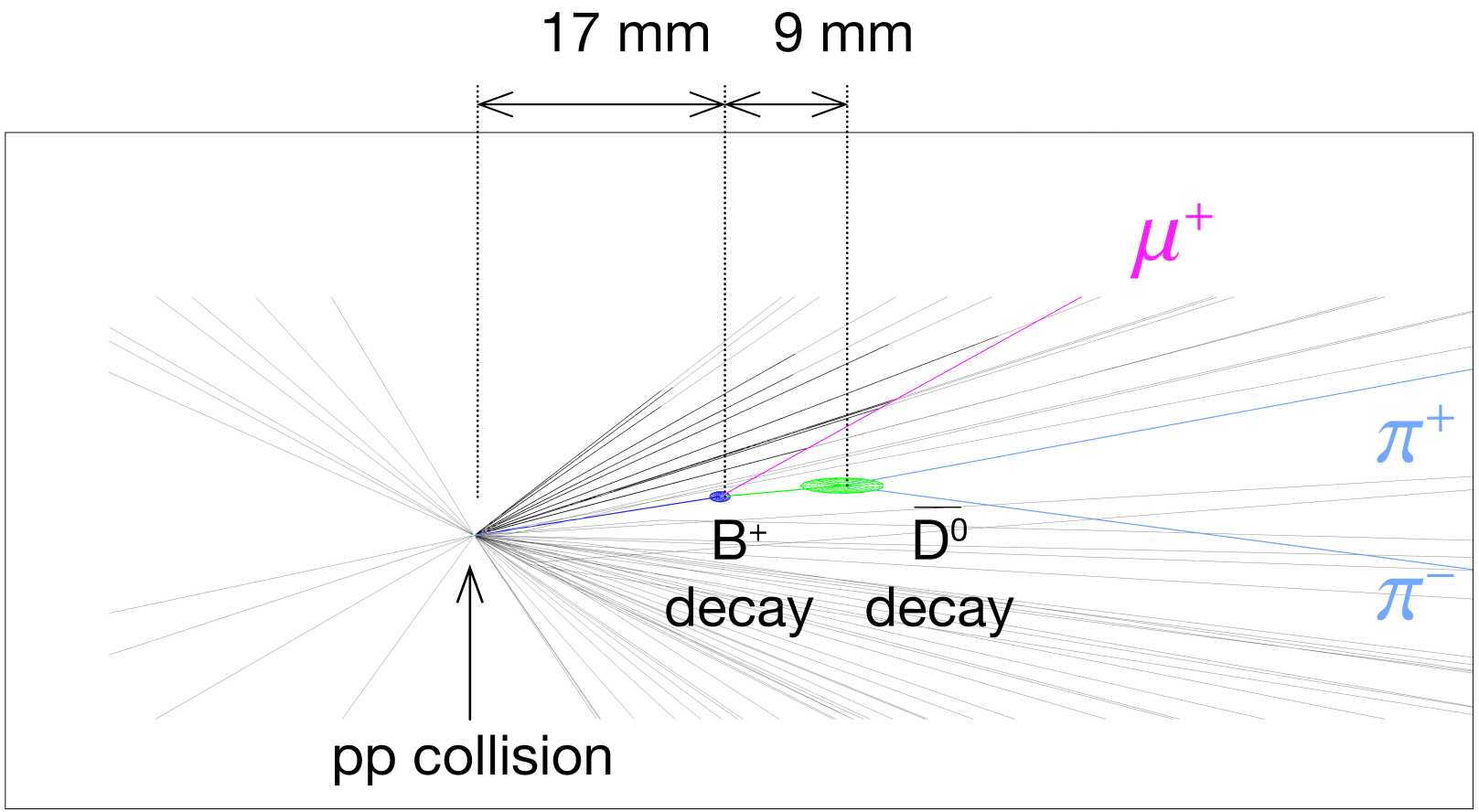
APS DPF meeting 2017

Introduction

- Semileptonic b-hadron decays important tests of the Standard Model:
  - Measure quark mixing CKM matrix elements $|V_{cb}|$, $|V_{ub}|$
  - Validate understanding of QCD in decays
- Can study lepton flavor universality in charged current
- LHCb produces large data sets of b-hadron decays of all types
- Large semileptonic branching fractions $\approx 10\%$ allow them to be used for other measurements

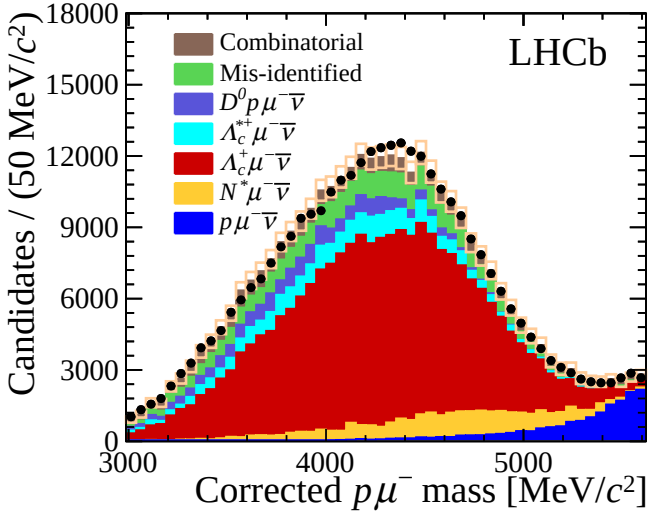
At LHCb

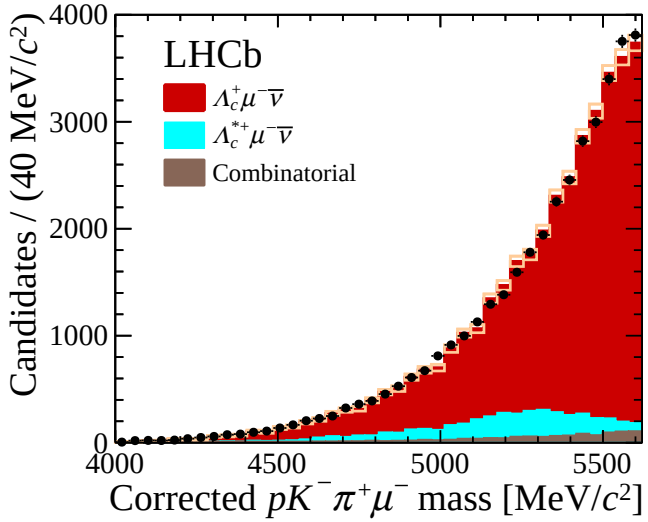
- Excellent vertexing and particle ID enable selection



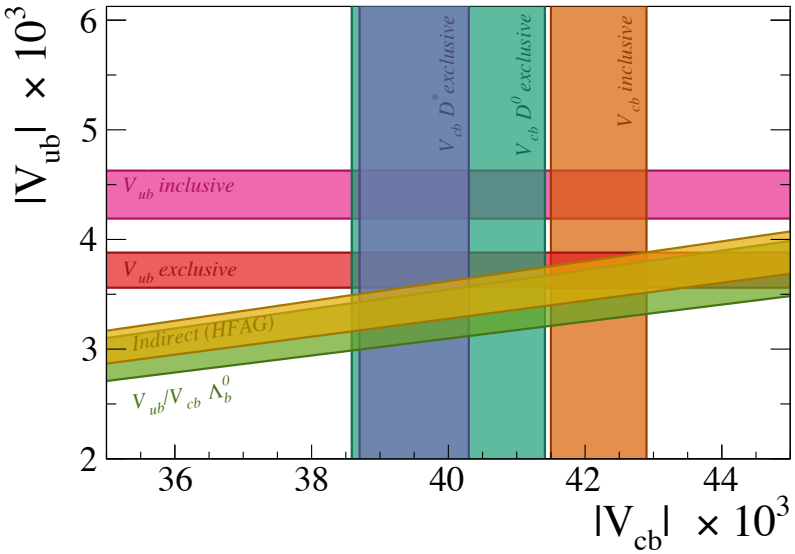
$|V_{ub}|$ with baryons

First such measurement





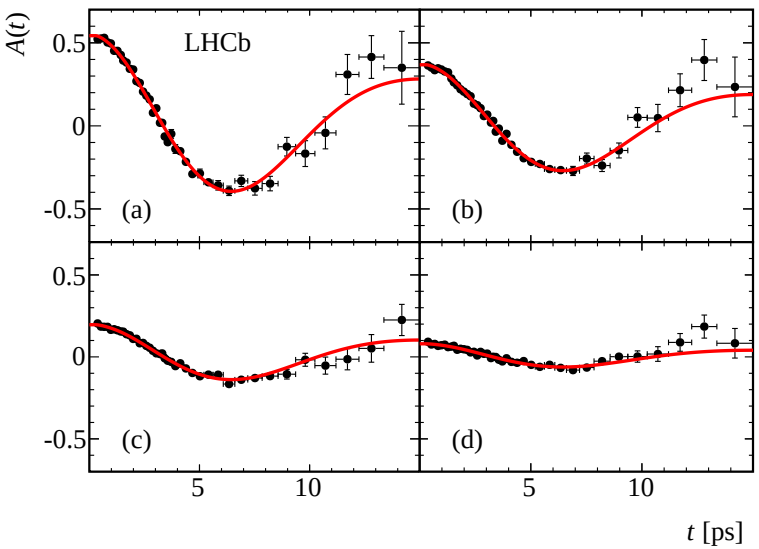
- Ratio $\Lambda_b^0 \to p\mu\nu / \Lambda_b^0 \to \Lambda_c^+\mu\nu$
- Main backgrounds also semileptonic



Tagging decay flavor

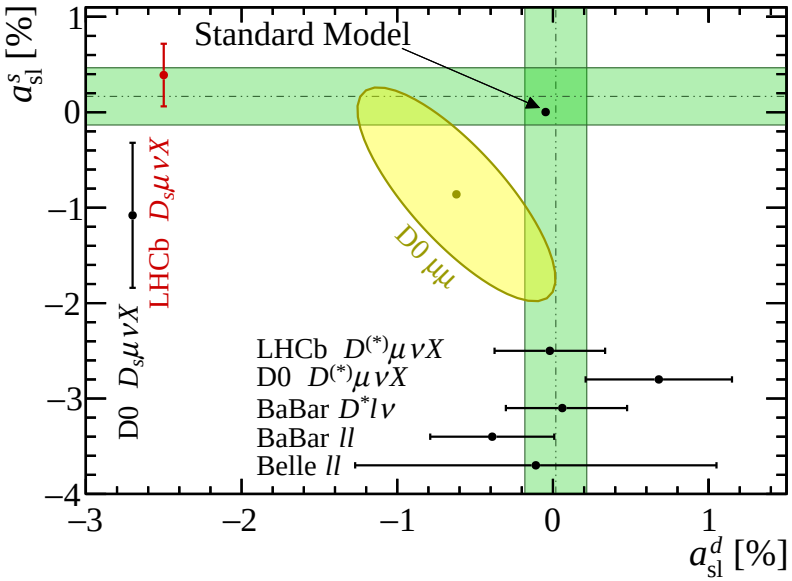
Allows mixing studies

$$\Delta m_d = (505.0 \pm 2.1 \pm 1.0)\ \mathrm{ns}^{-1}$$



Eur. Phys. J. C (2016) 76: 412

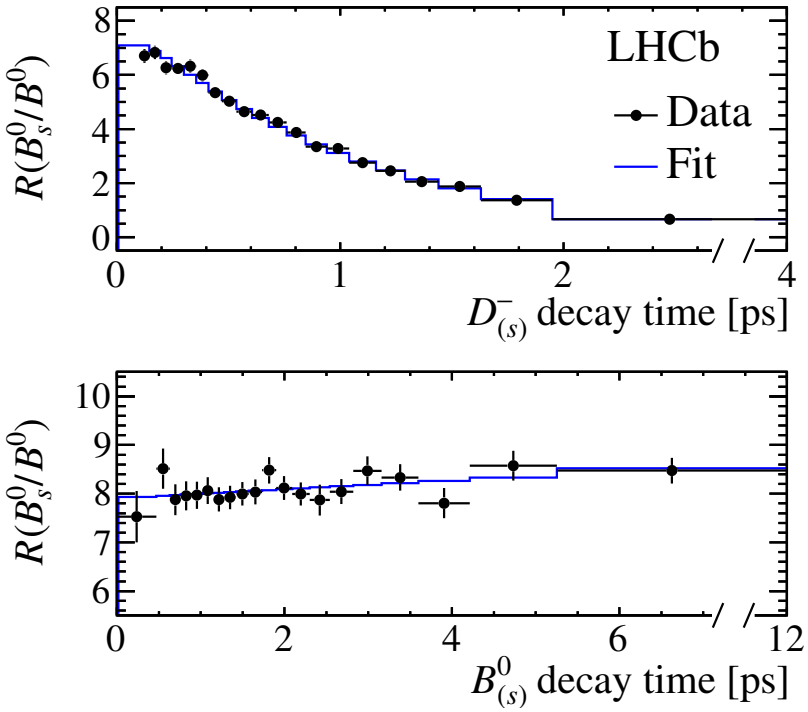
CP violation in mixing



Phys. Rev. Lett. 117 (2016), 061803

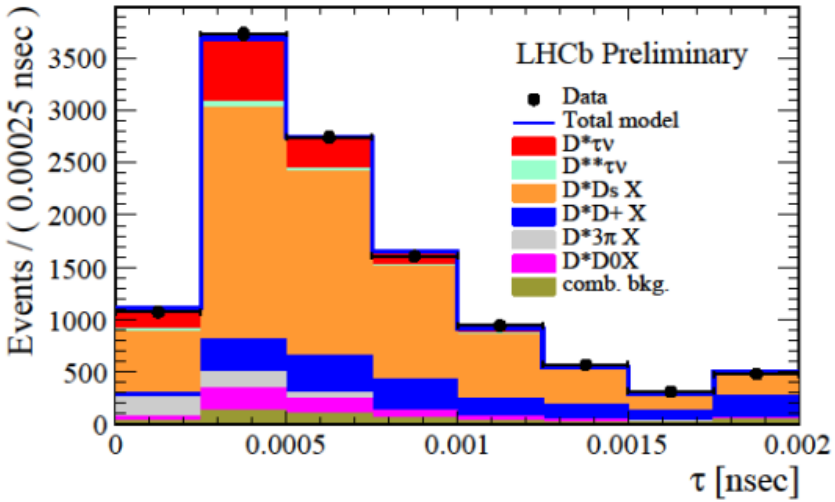
Other talks

- Lifetime of B_s^0 and D_s^+



D. Tonelli on 8/1
arXiv:1705.03475

- Lepton universality – τ/μ



B. Siddi on 8/2
LHCb-PAPER-2017-017

$\Lambda_b^0 \to \Lambda_c^+ \mu \nu$

Form factor measurement

NEW!

- Differential distributions key for comparisons with Heavy Quark Effect Theory and Lattice QCD
- Necessary to measure CKM quark mixing parameters (overall factor G)
- Measure form-factors as one Isgur-Wise function ξ_B:

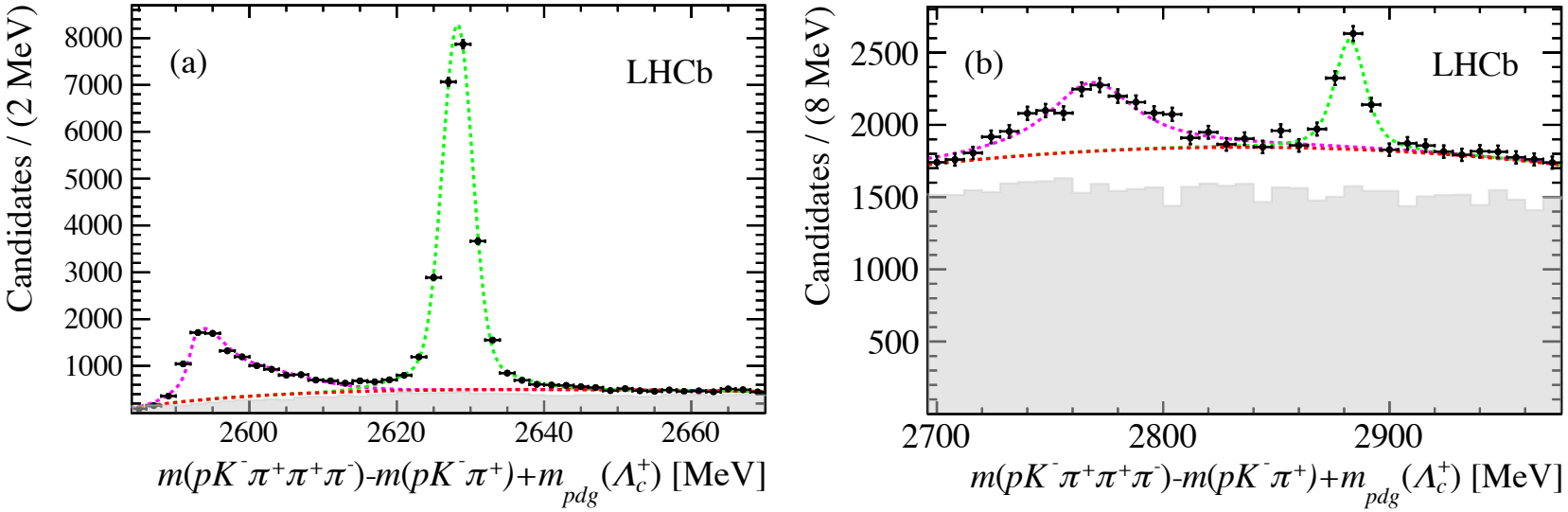
$$\frac{\mathrm{d}\Gamma}{\mathrm{d}w} = G K(w) \xi_B^2(w) \qquad w = \frac{m^2_{\Lambda_b^0} + m^2_{\Lambda_c^+} - q^2}{2 m_{\Lambda_b^0} m_{\Lambda_c^+}}$$

Kinematic factor

$q^2 =$ momentum transfer^2

Backgrounds are interesting!

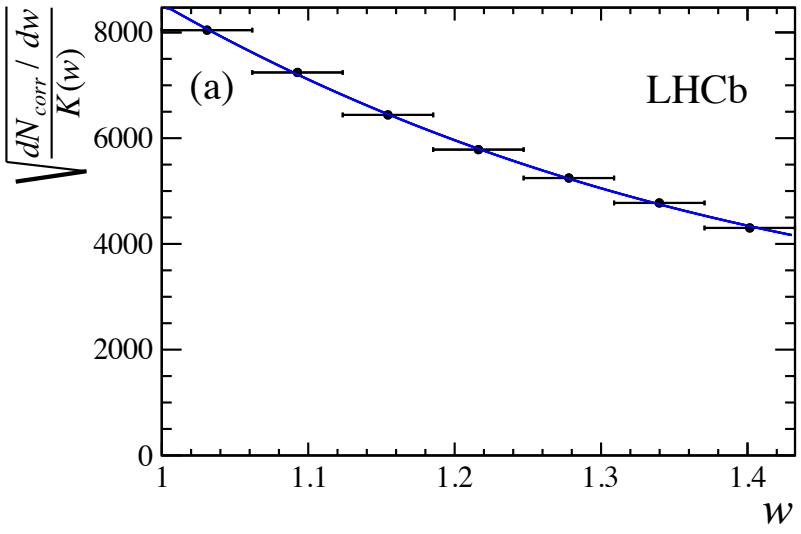
- Excited states are backgrounds to ground state decay
- Measure excited Λ_c^{**+} with $\Lambda_c^+\pi^+\pi^-$



- $\Lambda_c(2765)^+$ not well measured previously

Unfolding to w

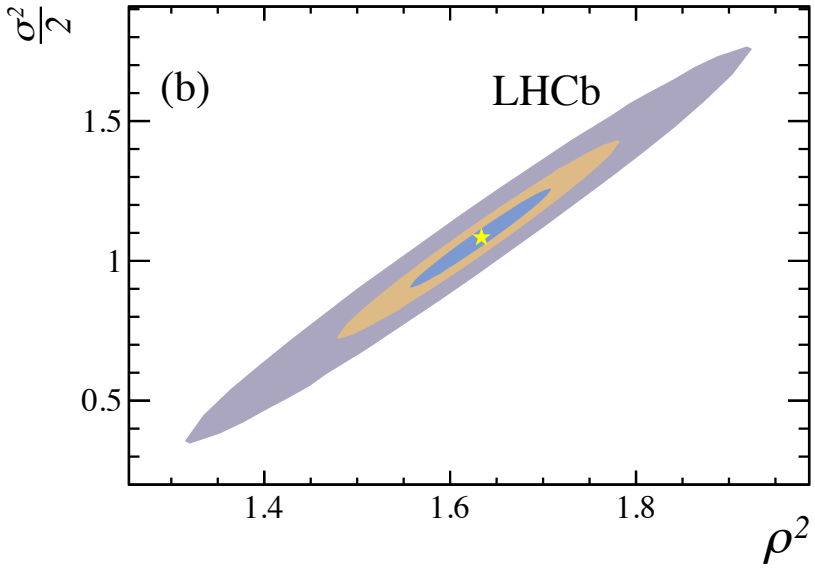
- Unfold using Singular Value Decomposition
- Corrected for acceptance and efficiency
- Final w distribution fit with multiple ansatz



Slope of ξ_B

- Slope of ξ_B at $w = 1$ is key observable
- Measured:

$$\rho^2 = 1.63 \pm 0.07 \pm 0.08$$



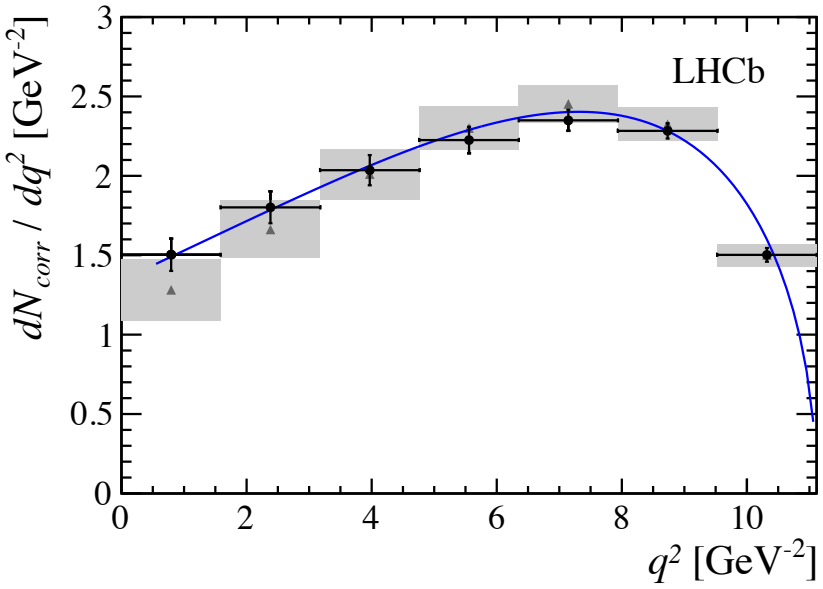
Theory:

Lattice[1]	QCD sum rules[2]	HQET[3]
$\rho^2 = 1.2^{+0.8}_{-1.1}$	1.35 ± 0.13	1.51

[1] Phys. Rev. D57 (1998) 6948, [2] Phys. Lett. B629 (2005) 27, [3] Phys. Rev. D73 (2006) 094002

Comparison to lattice

- Unfold also to q^2
- Comparison with lattice calculation[1] (gray band)
- Also described by single form factor fit (blue line)
- Future studies with normalization channel can extract $|V_{cb}|$



Conclusion

- Semileptonic decays are an interesting and broad subject at LHCb
- Allow measurements of:
  - CKM quark mixing elements
  - QCD form factors
  - Lepton universality
- Large cross-sections useful for other measurements:
  - Meson mixing
  - Lifetime
  - Excited charm
- NEW: Λ_b^0 form factor measurement