Towards a Measurement of V_{ub} with LHCb

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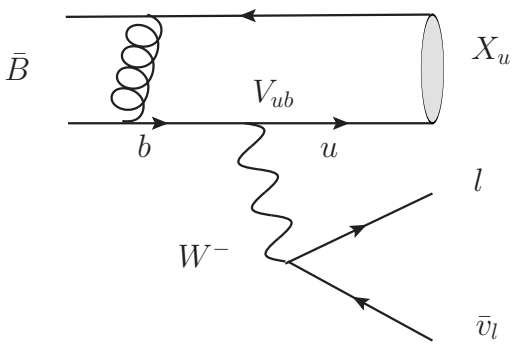
Outline

1. Background and motivation.
2. Previous measurements.
3. V_{ub} with LHCb
4. Initial generator level study

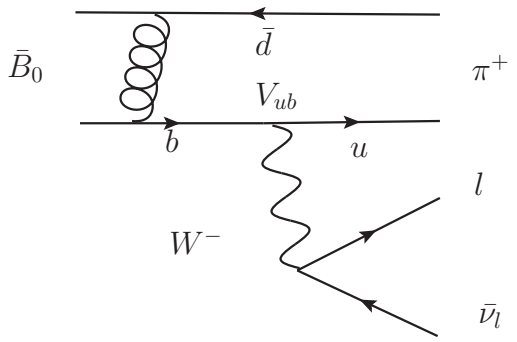
1 - Current Status of $|V_{ub}|$

- Semi-Leptonic B Decays:

Inclusive ($\bar{B} \to X_u l \bar{\nu}_l$)

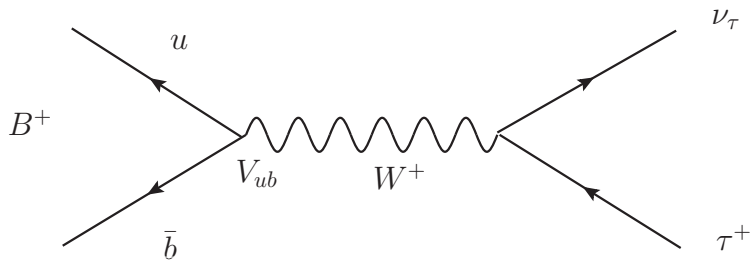


Exclusive ($\bar{B}_0 \to \pi^+ l \bar{\nu}_l$)



$|V_{ub}| = (4.41 \pm 0.15^{+0.15}_{-0.17}) \times 10^{-3}$ $|V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$

- Leptonic B decays ($B^+ \to \tau^+ \nu_\tau$):

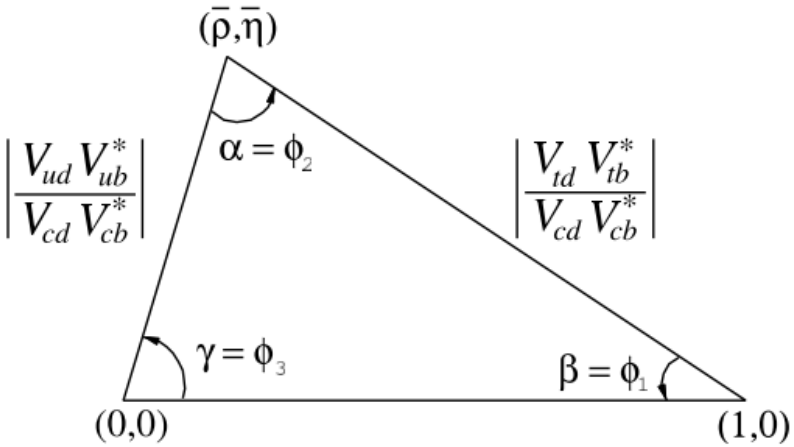


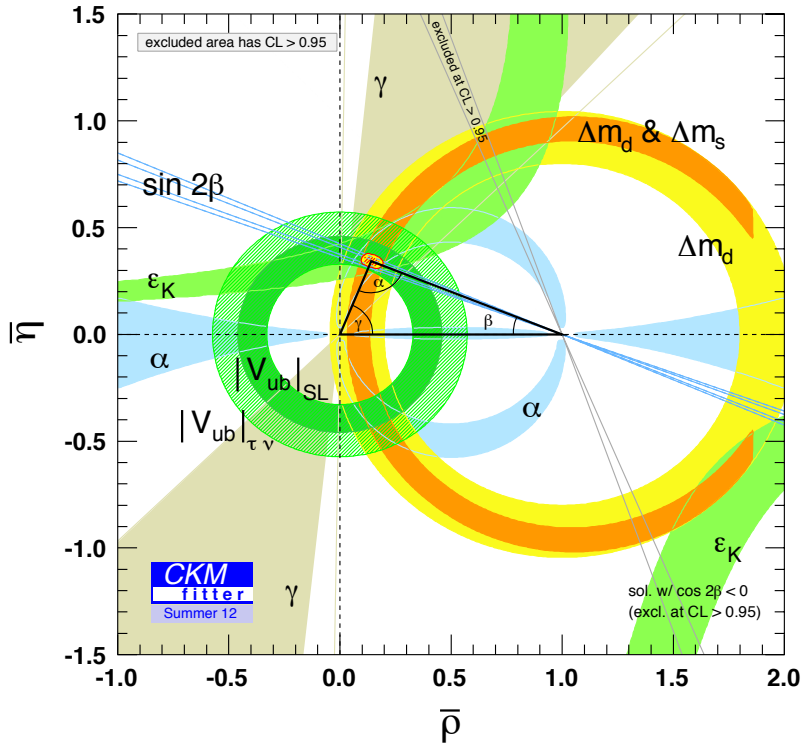
1 - $|V_{ub}|$ Constraints on the Unitarity Triangle

- $V_{CKM} V_{CKM}^{\dagger} = \mathbb{1} \implies$

  $V_{ud} V_{ub}^{*} + V_{cd} V_{cb}^{*} + V_{td} V_{tb}^{*} = 0$

  $(+ \ 5 \text{ others})$





[1] CKMfitter Group, J. Charles et al. ICHEP conference (July 2012)

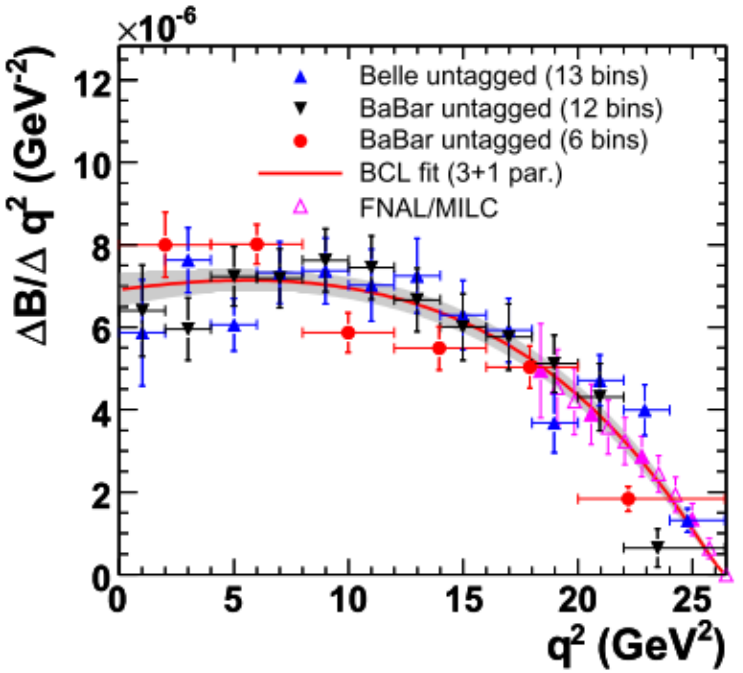
2 - Inclusive Measurements of V_{ub}

- e^+e^- B factories BaBar and Belle:
  $|V_{ub}| = (4.41 \pm 0.15^{+0.15}_{-0.17}) \times 10^{-3}$
- Inclusive Approach:
  - Measure partial branching fraction, $\Delta B(B \to X_u l^- \nu)$.
  - Large background $B \to X_c l^- \nu$.
  - Exploit kinematic endpoint of $B \to X_c l^- \nu$.
  - Extrapolate to full phase space.
  - Dominate uncertainty due to uncertainty on m_b.

2- Exclusive Measurements of $|V_{ub}|$

- BaBar, Belle and CLEO: $|V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$
- Exclusive Approach:
  - Exclusive final state $(\bar{B}_0 \to \pi^+ l^- \bar{\nu}_l)$
  - $\frac{d\Gamma}{dq^2} = \frac{G_F^2 |V_{ub}|^2}{24\pi^3} |p_\pi|^3 |f_+(q^2)|^2$
  - $|f_+(q^2)|^2$ predicted by lattice QCD
  - Uncertainty dominated by $|f_+(q^2)|^2$.

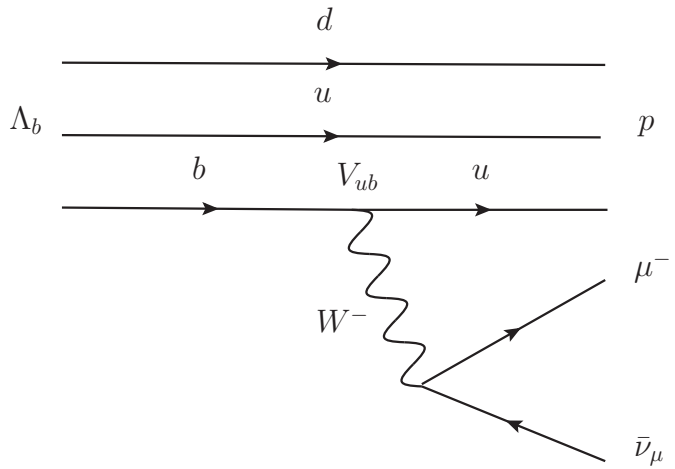
Measured partial branching fraction $\Delta B(\bar{B}_0 \to \pi^+ l^- \bar{\nu}_l)$ [2]:



[2] J. Beringer et al., Determination of V_{ub} and V_{cb} (Particle Data Group). *Phys. Rev.* D**86**, 010001 (2012).

3 - $|V_{ub}|$ with LHCb

- Large pion backgrounds.
- Other possible decays: $\Lambda_b \to p\mu^-\bar{\nu}_\mu$ and $\bar{B}_s \to K^+\mu^-\bar{\nu}_\mu$

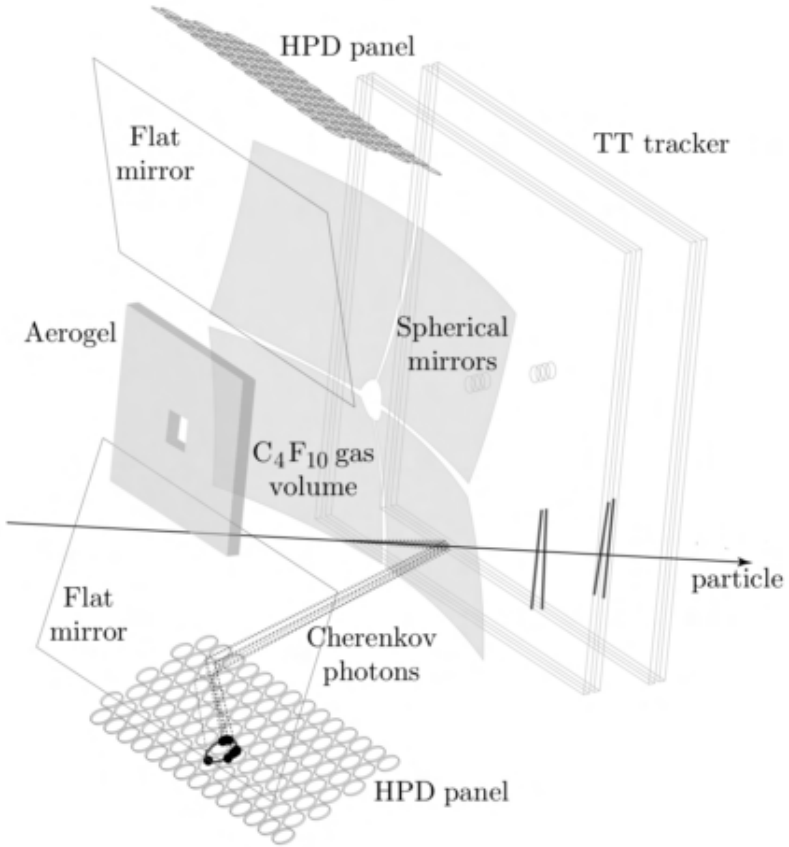


- Advantages of $\Lambda_b \to p\mu^-\bar{\nu}_\mu$:
  - $f_{\Lambda_b}/(f_u + f_d) \sim 0.40$ and $f_{\Lambda_b}/f_s \sim 3$
  - Proton provides a more distinctive final-state.

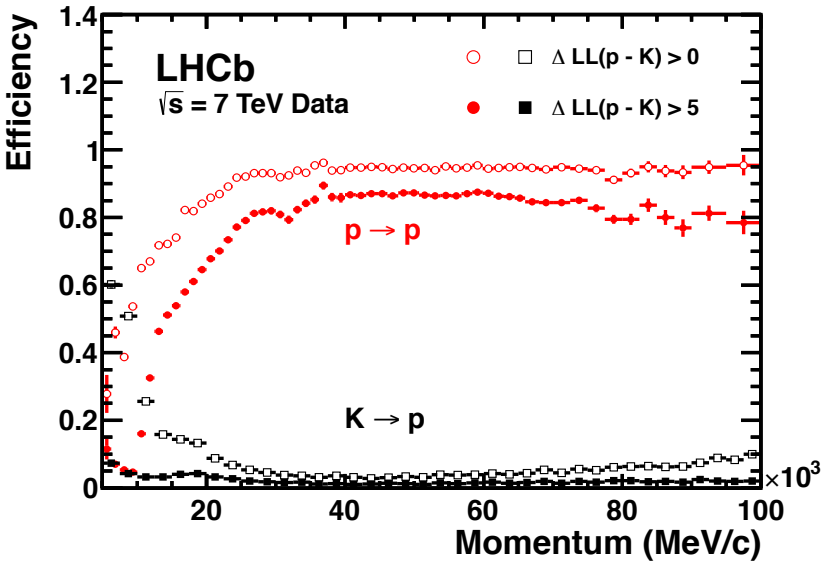
3 - $\Lambda_b \to p\mu^- \bar{\nu}_\mu$ with LHCb

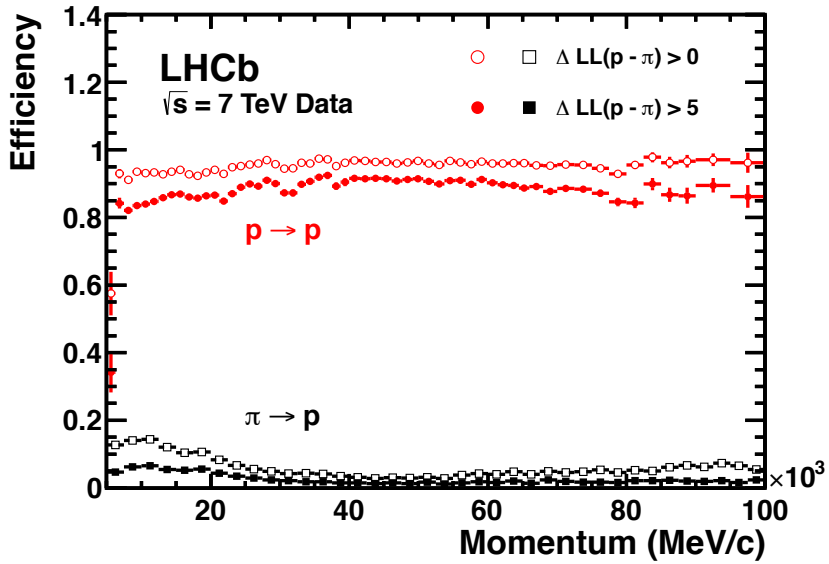
- Displaced secondary vertex.
- μ and p tracks.
- Muon systems
- 2 RICH detectors for PID
- Proton, kaon and pion separation
  $|\vec{p}| = 2 \to 100$ GeV/c

Schematic of RICH 1:



3 - RICH PID performance

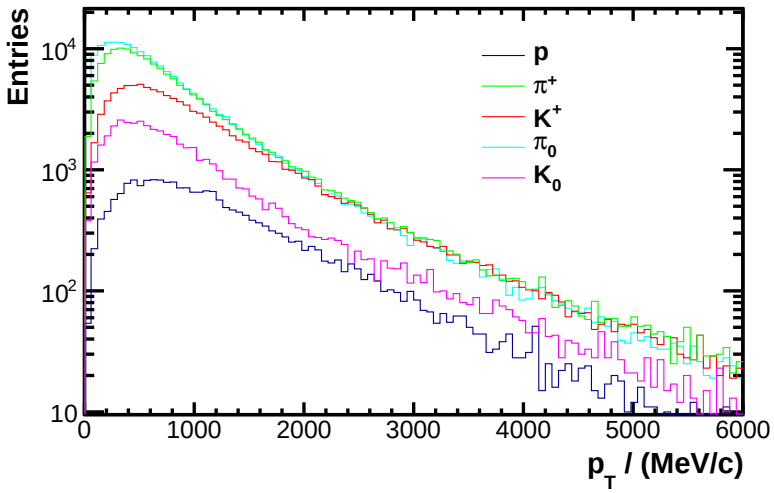


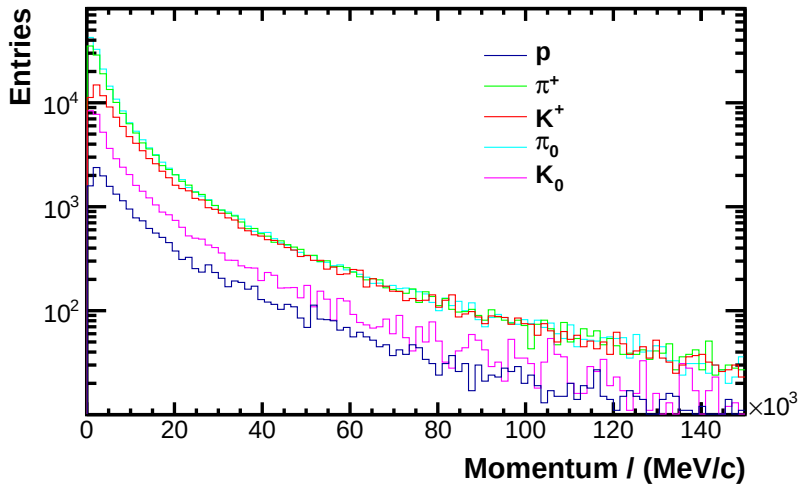


- High K-p misidentification rate below $10\,GeV/c$.

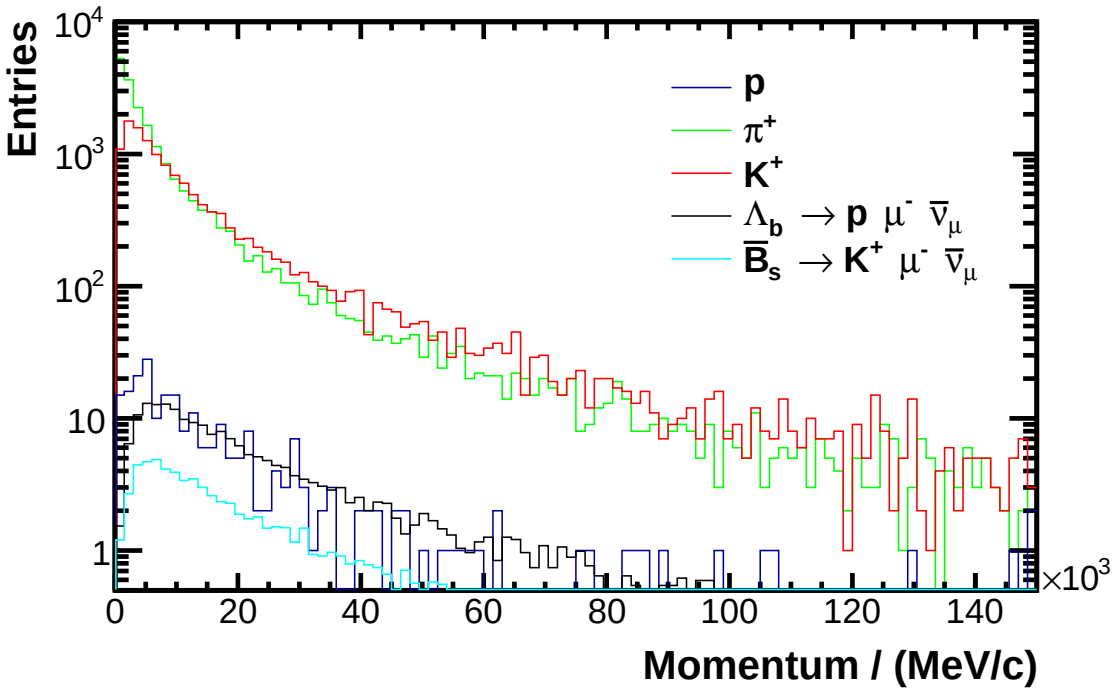
4 - Initial Generator Level Studies

- Generator level sample of pp to inclusive B events.
  - At least one lepton with $p_T > 1.5$ GeV/c.
- Search for p, K^+ and π^+ from the decay chain of a B hadron.





- Require p, K^+ and π^+ to vertex with a muon with $p_T > 1.5$ GeV/c.
- Plot signal samples of $\Lambda_b \to p\mu^-\bar{\nu}_\mu$ and $\bar{B}_s \to K^+\mu^-\bar{\nu}_\mu$
- Weight signal samples using:
  - $B(\Lambda_b \to p\mu^-\bar{\nu}_\mu) \approx B(B_s \to K^+\mu^-\bar{\nu}_\mu) \sim 10^{-4}$
  - Efficiencies of generator level cuts.
  - Λ_b and B_s production fractions.



Conclusion

- $|V_{ub}|$ is important constraining for CKM physics.
- $\sim 3\sigma$ discrepancy between exclusive and inclusive measurements.
- Yet to be observed $\Lambda_b \to p\mu^- \bar{\nu}_\mu$ is a promising decay.
- Generator level studies indicate that proton backgrounds are low.
- Future Work:
  - Determine exact selection criteria for a measurement of $\Delta B(\Lambda_b \to p\mu^- \bar{\nu}_\mu)$.

Thanks for listening. Any questions?