

# Towards a Measurement of $V_{ub}$ with LHCb



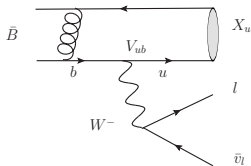
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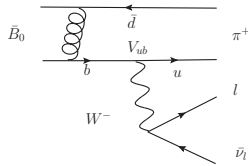
1. Background and motivation.
2. Previous measurements.
3.  $V_{ub}$  with LHCb
4. Initial generator level study

► Semi-Leptonic B Decays:

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

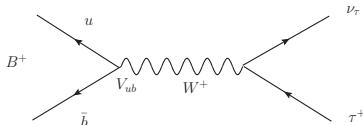


Exclusive ( $\bar{B}_0 \rightarrow \pi^+ l \bar{\nu}_l$ )



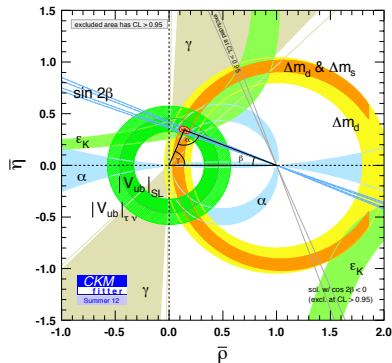
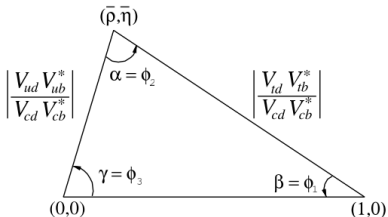
$$|V_{ub}| = (4.41 \pm 0.15^{+0.15}_{-0.17}) \times 10^{-3} \quad |V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$$

► Leptonic B decays ( $B^+ \rightarrow \tau^+ \nu_\tau$ ):



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

$\triangleright V_{CKM} V_{CKM}^\dagger = \mathbb{1} \implies$   
 $V_{ud} V_{ub}^* + V_{cd} V_{cb}^* + V_{td} V_{tb}^* = 0$   
 (+ 5 others)



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

- ▶  $e^+e^-$  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,  $\Delta B(B \rightarrow X_u l^- \nu)$ .
- Large background  $B \rightarrow X_c l^- \nu$ .
- Exploit kinematic endpoint of  $B \rightarrow X_c l^- \nu$ .
- Extrapolate to full phase space.
- Dominate uncertainty due to uncertainty on  $m_b$ .

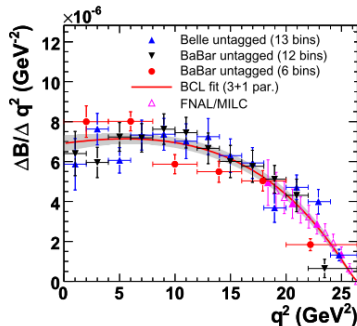
## 2- Exclusive Measurements of $|V_{ub}|$

- ▶ BaBar, Belle and CLEO:  
 $|V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$

- ▶ Exclusive Approach:

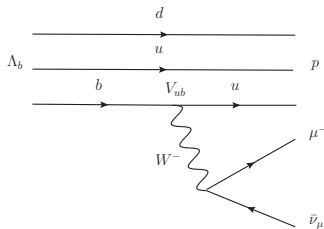
- Exclusive final state  
( $\bar{B}_0 \rightarrow \pi^+ l^- \bar{\nu}_l$ )
- $\frac{d\Gamma}{dq^2} =$   
 $\frac{G_F^2 |V_{ub}|^2}{24\pi^3} |p_\pi|^3 |f_+(q^2)|^2$
- $|f_+(q^2)|^2$  predicted by  
lattice QCD
- Uncertainty dominated by  
 $|f_+(q^2)|^2$ .

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



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

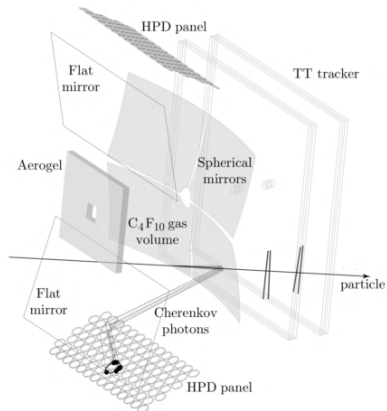
- ▶ Large pion backgrounds.
- ▶ Other possible decays:  $\Lambda_b \rightarrow p\mu^-\bar{\nu}_\mu$  and  $\bar{B}_s \rightarrow K^+\mu^-\bar{\nu}_\mu$



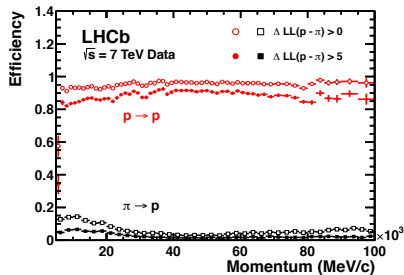
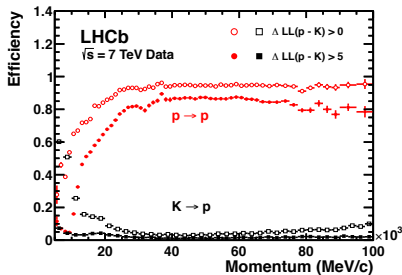
- ▶ Advantages of  $\Lambda_b \rightarrow p\mu^-\bar{\nu}_\mu$ :
  - $f_{\Lambda_b}/(f_u + f_d) \sim 0.40$  and  $f_{\Lambda_b}/f_s \sim 3$
  - Proton provides a more distinctive final-state.

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

Schematic of RICH 1:

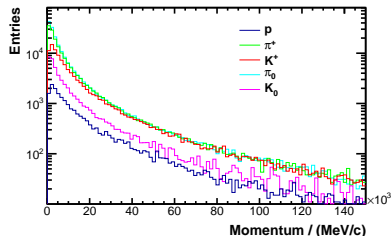
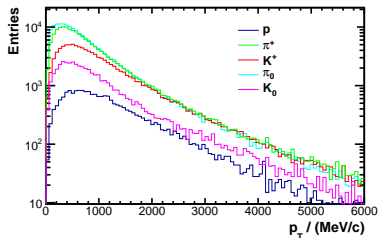




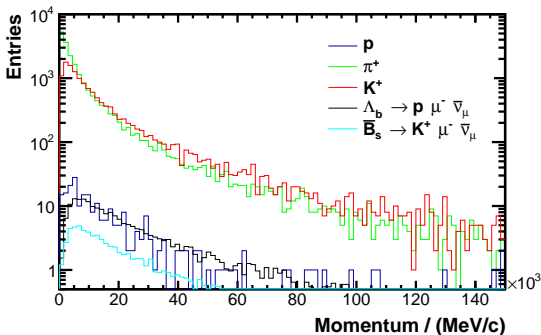


- High  $K$ - $p$  misidentification rate below 10 GeV/c.

- ▶ 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  $\pi^+$  from the decay chain of a B hadron.



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



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

Thanks for listening. Any questions?