

Towards a measurement of $|V_{ub}|$ with $\Lambda_b \rightarrow p\mu\nu$



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March 20, 2013

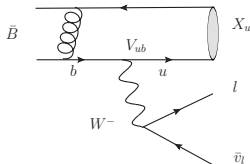
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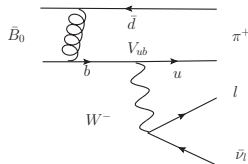
Current Status of $|V_{ub}|$

► Semi-Leptonic B Decays:

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



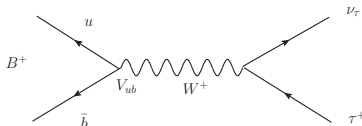
Exclusive ($\bar{B}_0 \rightarrow \pi^+ l \bar{\nu}_l$)



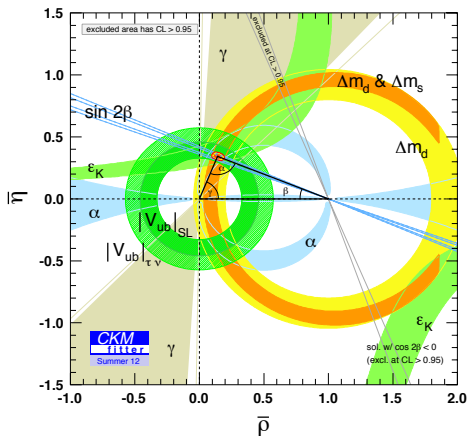
$$|V_{ub}| = (4.41 \pm 0.15^{+0.15}_{-0.17}) \times 10^{-3}$$

$$|V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$$

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



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



Exclusive Measurements of $|V_{ub}|$

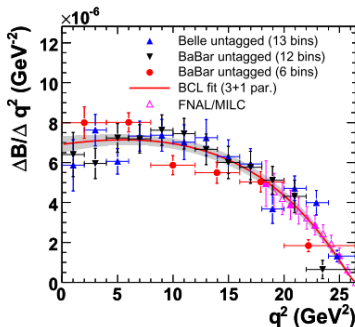
- ▶ BaBar, Belle and CLEO:
 $|V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$

- ▶ 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

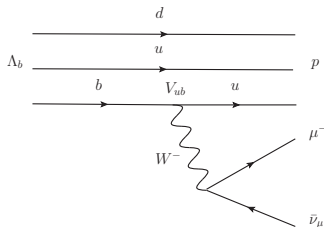
- ▶ Uncertainty dominated by $|f_+(q^2)|^2$. Lattice QCD predictions best at high q^2 .

Measured partial branching fraction [2]:



$|V_{ub}|$ with LHCb

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



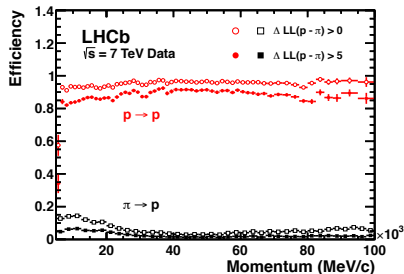
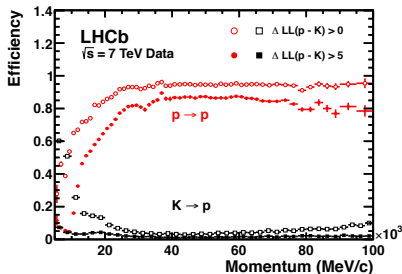
- ▶ Advantages of $\Lambda_b \rightarrow p\mu^-\bar{\nu}_\mu$:
 - $f_{\Lambda_b}/(f_u + f_d) \sim 0.40$ and $f_{\Lambda_b}/f_s \sim 3$
 - Proton provides a more distinctive final-state.

Current $B_s \rightarrow K\mu\nu$ Stripping Selection

Kaon cuts	Muon cuts	Mother cuts
$P > 3000 \text{ MeV}/c$	$P > 3000 \text{ MeV}/c$	$\cos\theta_{B_s(K\mu)} > 0.99$
$p_T > 800 \text{ MeV}/c$	$p_T > 800 \text{ MeV}/c$	$E_\nu < 2000 \text{ MeV}$
Track $\chi^2 < 6.0$	Track $\chi^2 < 4.0$	Vertex $\chi^2 < 2.0$
Min IP $\chi^2 > 16.0$	Min IP $\chi^2 > 12.0$	$\chi^2 \text{ sep. from PV} > 100.0$
$\Delta LL(K - p) > 0$	$\Delta LL(\mu - p) > 0$	$\leq M_{K\mu} \leq 5500 \text{ MeV}/c^2$
$\Delta LL(K - \pi) > 5$	$\Delta LL(\mu - \pi) > 3$	
$\Delta LL(K - \mu) > 0$	$\Delta LL(\mu - K) > 0$	

- ▶ StdLooseMuons and StdLooseKaons selections also used.
- ▶ Track Ghost probability < 0.5
- ▶ Prescaled by a factor of 0.5.

RICH PID performance



- High K - p misidentification rate / low p - p identification efficiency below 15 GeV/c.

Stripping Efficiency for Signal

- ▶ No available $\Lambda_b \rightarrow p\mu\nu$ MC sample yet.
- ▶ Strip $B_s \rightarrow K\mu\nu$ 2011 MC sample using existing line + $P_K > 10$ GeV/c.
- ▶ Signal Efficiency for stripping: $7.2 \pm 0.1\%$.
- ▶ Full efficiency in 4π , $\epsilon \approx 1.4\%$.

- ▶ In 1 fb^{-1} expect:

$$N_{\text{Events}} = 2 \times \sigma(b\bar{b}) \times f_{\Lambda_b} \times \mathcal{L} \times B(\Lambda_b \rightarrow p\mu^-\bar{\nu}) \times \epsilon$$

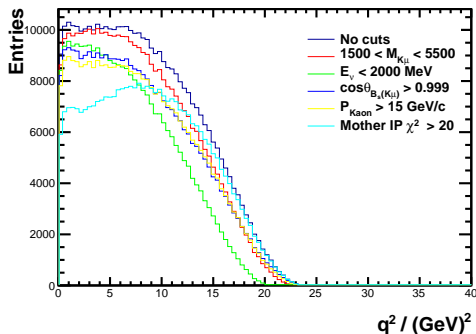
Taking $f_{\Lambda_b} \sim 0.25$, $B(\Lambda_b \rightarrow p\mu^-\bar{\nu}) \sim 10^{-4}$, $\sigma(b\bar{b}) \sim 280 \mu\text{b}$

$$N_{\text{Events}} \approx 2 \times 10^5$$

- ▶ Belle: 21486 ± 548 signal events, Phys. Rev. D 83, 071101(R) (2011)

Effect of Cuts on q^2 Distribution.

- ▶ Remove following cuts from the stripping:
 $1500 \text{ MeV}/c^2 \leq M_{K\mu} \leq 5500 \text{ MeV}/c^2$, $\cos\theta_{B_s\gamma} > 0.99$,
 $E_\nu < 2000 \text{ MeV}$
- ▶ Plot shows the effect of individual cuts on the q^2 distribution.



$\Lambda_b \rightarrow p\mu\nu$ Line

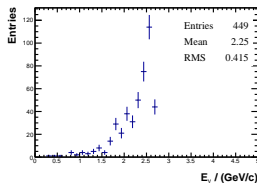
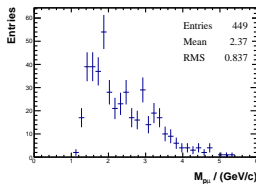
- ▶ Base selection on the current $B_s \rightarrow K\mu\nu$ line.
- ▶ Remove E_ν cut. Demand $P_{proton} > 15$ GeV/c and $1000 \text{ MeV}/c^2 \leq M_{p\mu} \leq 5600 \text{ MeV}/c^2$.
- ▶ Test using TestMyStrippingLineOn2012Data_Reco14.py script (100,000 events):

$L_b \rightarrow p\mu\nu$ line	Retention (%)	Accepted	ms/evt
Above cuts	0.449	449	0.474
$2000 \text{ MeV}/c^2 \leq M_{p\mu}$	0.246	246	0.386

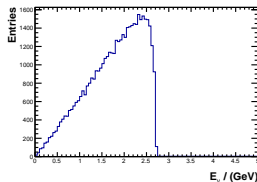
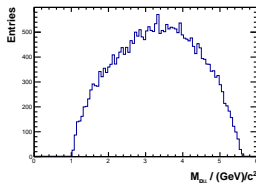
- ▶ Required retention $< 0.05\%$ and timing < 0.5 ms/evt.

$M_{p\mu}$ and E_ν Distributions

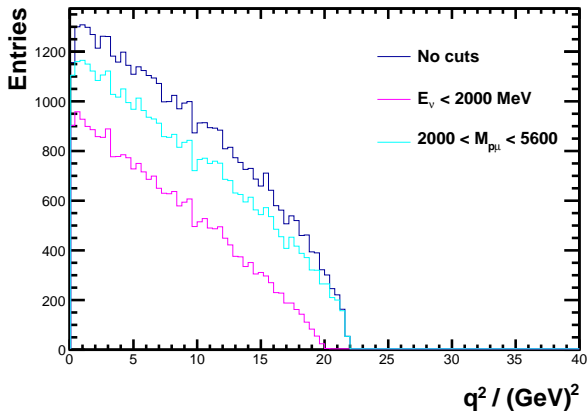
$M_{p\mu}$ and E_ν Distributions using 2012 test data



$M_{p\mu}$ and E_ν Distributions for generator level $\Lambda_b \rightarrow p \mu \nu$



$\Lambda_b \rightarrow p\mu\nu$ Generator Level q^2 Distribution



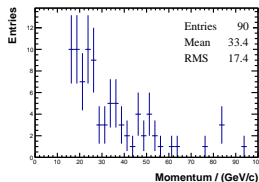
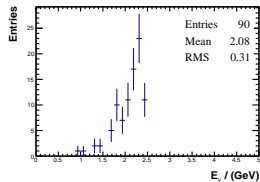
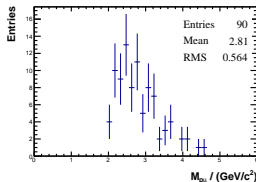
$\Lambda_b \rightarrow p\mu\nu$ Line: Proposed Selection

Proton cuts	Muon cuts	Mother cuts
$P > 15000 \text{ MeV}/c$	$P > 3000 \text{ MeV}/c$	$\cos\theta_{B_s(p\mu)} > 0.999$
$p_T > 1000 \text{ MeV}/c$	$p_T > 1400 \text{ MeV}/c$	IP $\chi^2 > 16.0$
Track $\chi^2 < 6.0$	Track $\chi^2 < 4.0$	Vertex $\chi^2 < 3.0$
Min IP $\chi^2 > 16.0$	Min IP $\chi^2 > 12.0$	$\chi^2 \text{ sep. from PV} > 100.0$
$\Delta LL(p - K) > 0$	$\Delta LL(\mu - p) > 0$	$2000 \leq M_{p\mu} \leq 5500 \text{ MeV}/c^2$
$\Delta LL(p - \pi) > 5$	$\Delta LL(\mu - \pi) > 3$	$p_{T(p\mu)} > 1500 \text{ MeV}/c$
$\Delta LL(p - \mu) > 0$	$\Delta LL(\mu - K) > 0$	

- ▶ StdLooseMuons and StdLooseProtons selections.
- ▶ L0Muon & (Hlt2SingleMuon — Hlt2TopoMu2Body)
- ▶ Track Ghost probability < 0.5
- ▶ Includes both signed combinations.

$\Lambda_b \rightarrow p \mu \nu$ Line: Tightened Selection

$L_b \rightarrow p \mu \nu$ line	Retention (%)	Accepted	ms/evt
Tightened Selection	0.09	90	1.215



Conclusion

- ▶ $\Lambda_b \rightarrow p\mu\nu$ is a promising channel for an exclusive measurement of V_{ub} .
- ▶ Stripping line for $\Lambda_b \rightarrow p\mu\nu$ is almost ready.