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

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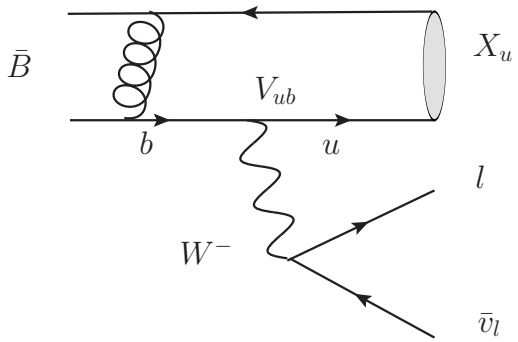
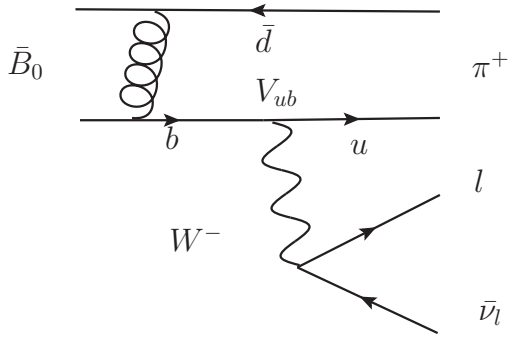
Current Status of $|V_{ub}|$

- Semi-Leptonic B Decays:

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

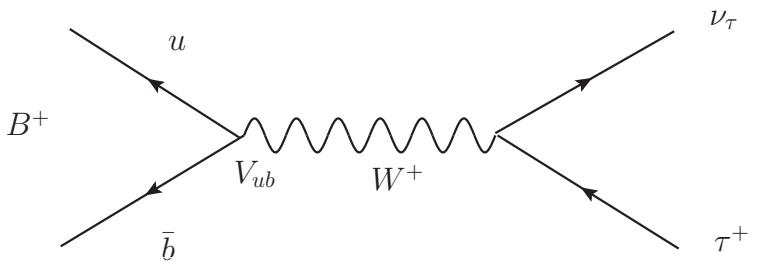


Exclusive ($\bar{B}_0 \to \pi^+ l \bar{\nu}_l$)

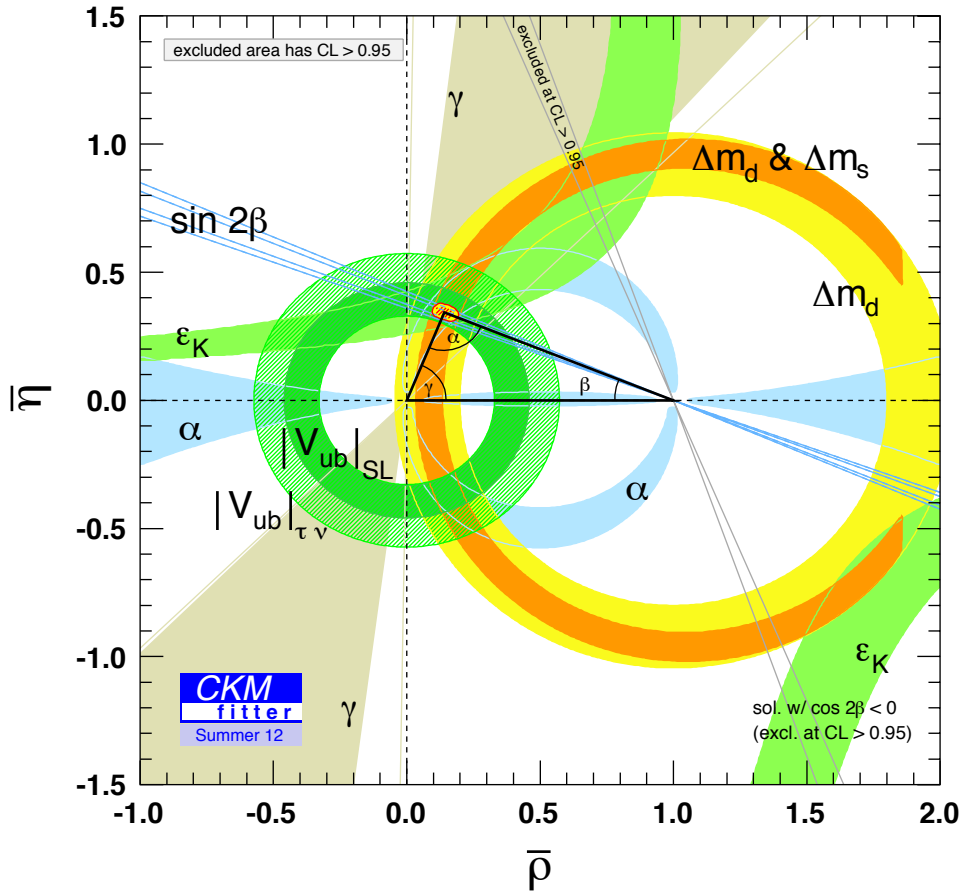


$|V_{ub}| = (4.41 \pm 0.15^{+0.15}_{-0.17}) \times 10^{-3}$ $|V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$

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



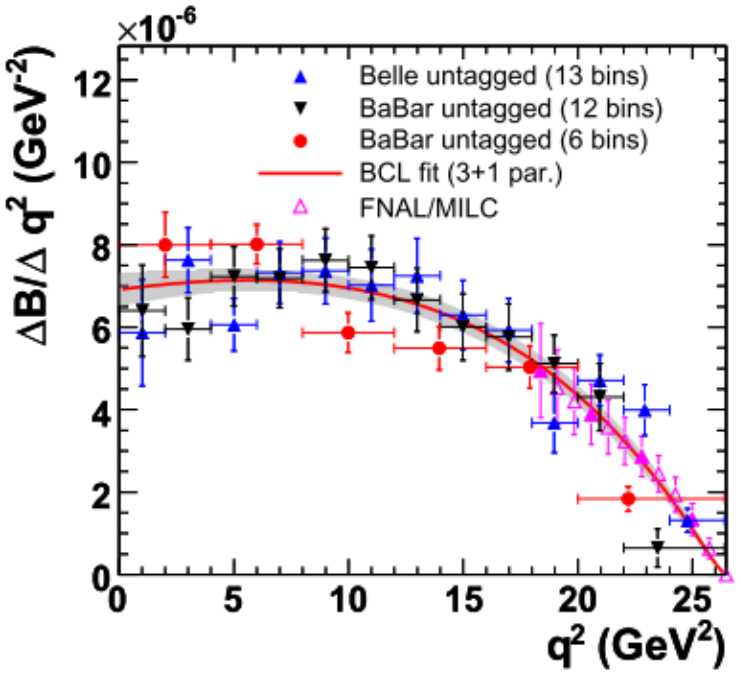
$|V_{ub}|$ Constraints on the Unitarity Triangle



Exclusive Measurements of $|V_{ub}|$

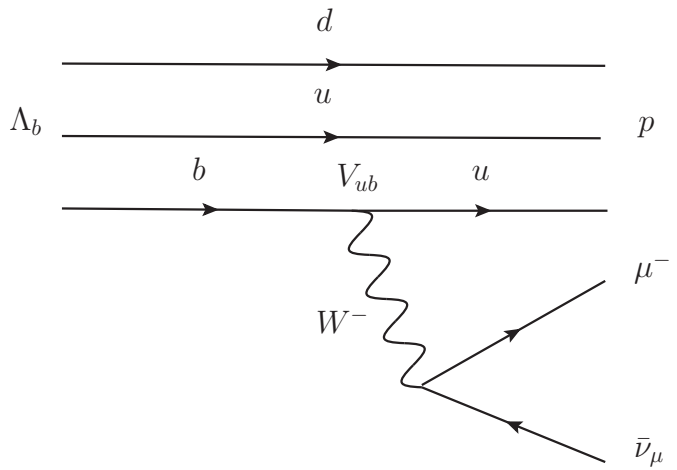
- BaBar, Belle and CLEO: $|V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$
- Exclusive Approach:
  - Exclusive final state $(\bar{B}_0 \to \pi^+ l^- \bar{\nu}_l)$
  - $\frac{d\Gamma}{dq^2} = \frac{G_F^2 |V_{ub}|^2}{24\pi^3} |p_\pi|^3 |f_+(q^2)|^2$
  - $|f_+(q^2)|^2$ predicted by lattice QCD
  - Uncertainty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

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



$|V_{ub}|$ with LHCb

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



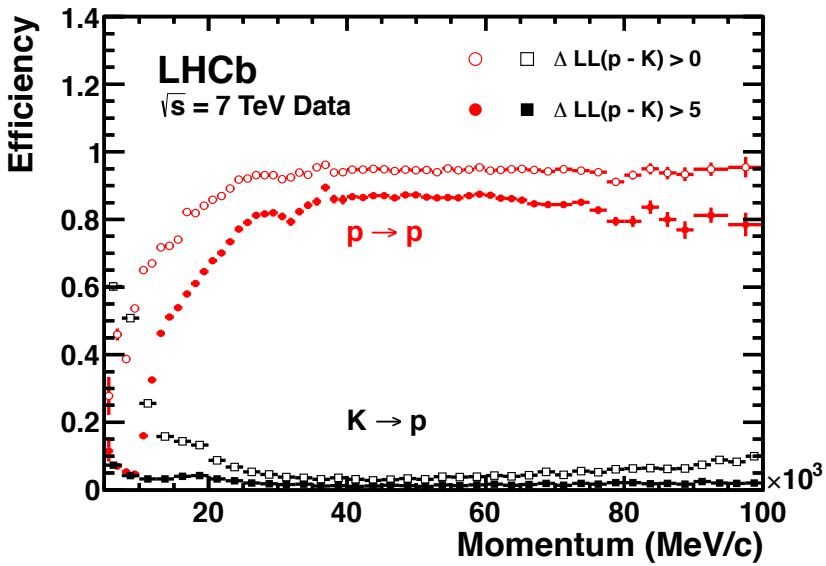
- Advantages of $\Lambda_b \to p\mu^-\bar{\nu}_\mu$:
  - $f_{\Lambda_b}/(f_u + f_d) \sim 0.40$ and $f_{\Lambda_b}/f_s \sim 3$
  - Proton provides a more distinctive final-state.

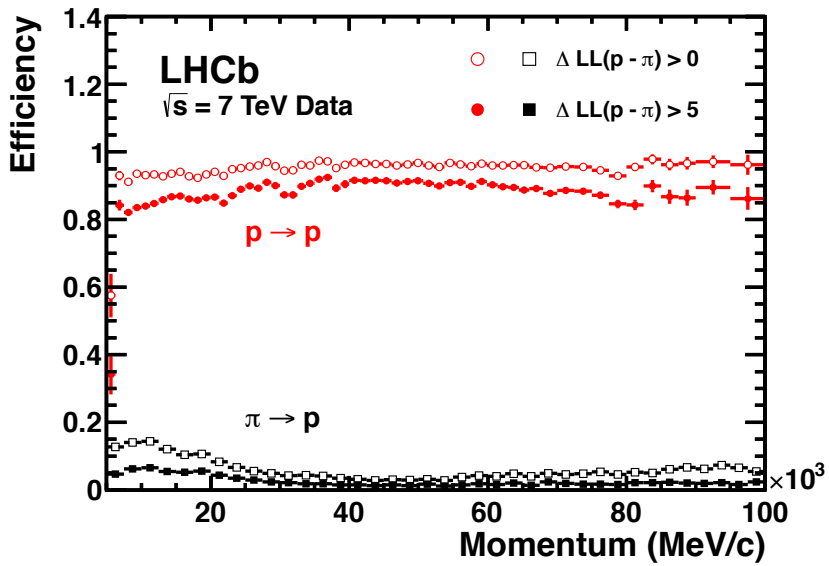
Current $B_s \to K\mu\nu$ Stripping Selection

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

- StdLooseMuons and StdLooseKaons selections also used.
- Track Ghost probability < 0.5
- Combination cut: $1500 MeV/c^2 \leq M_{K\mu} \leq 5500 MeV/c^2$.

RICH PID performance





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

Stripping Efficiency for Signal

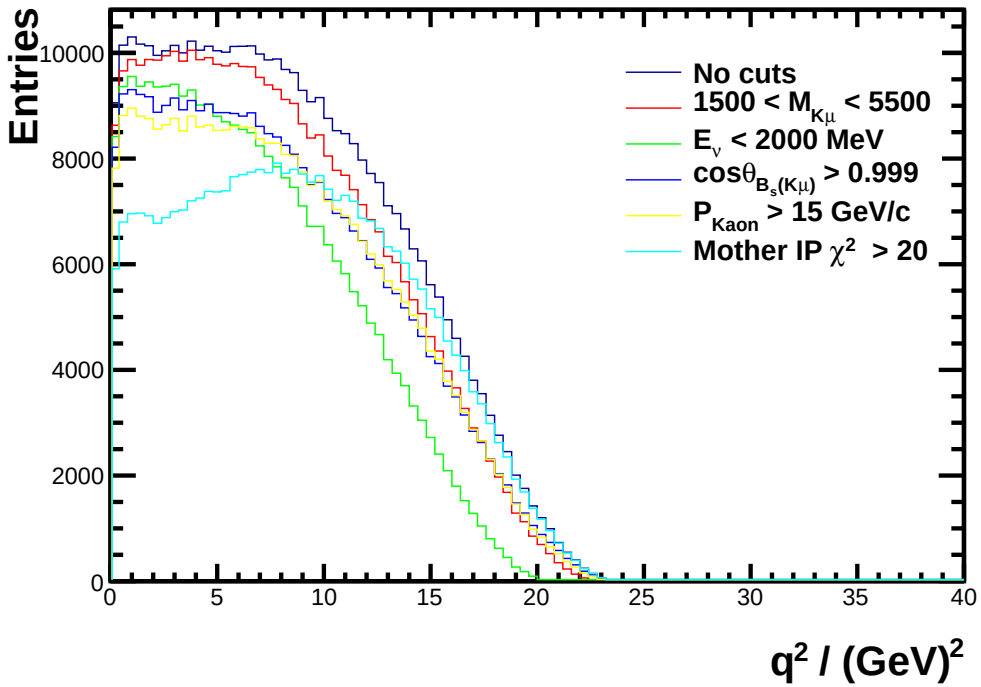
- No available $\Lambda_b \to p\mu\nu$ MC sample yet.
- Strip $B_s \to K\mu\nu$ 2011 MC sample using existing line + $P_K > 10$ GeV/c.
- Signal Efficiency for stripping: $7.2 \pm 0.1\%$.
- Acceptance, $A \approx 1.4\%$.
- In 1 fb^{-1} expect:
  $N_{Events} = 2 \times \sigma(b\bar{b}) \times f_{\Lambda_b} \times \mathcal{L} \times B(\Lambda_b \to p\mu^-\bar{\nu}) \times A$

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

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

Effects of cuts on q^2 distribution.

- Remove following cuts:
  $1500 MeV/c^2 \leq M_{K\mu} \leq 5500 MeV/c^2$, $cos\theta_{B_s Y} > 0.99$,
  $E_\nu < 2000$MeV



$\Lambda_b \to p\mu\nu$ Line

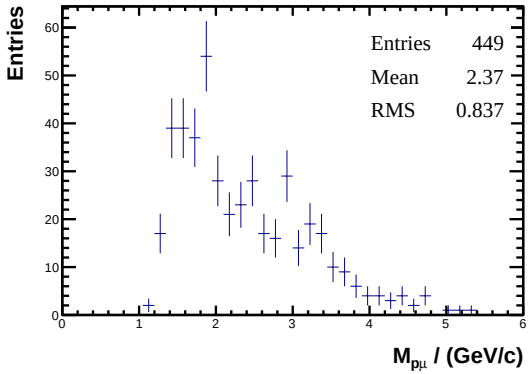
- Base selection on the current $B_s \to K\mu\nu$ line.
- Remove E_ν cut. Demand $P_{proton} > 15$ GeV/c and 1000 MeV/c^2 $\leq M_{p\mu} \leq$ 5600 MeV/c^2.
- Test using TestMyStrippingLineOn2012Data_Reco14.py script (100,000 events):

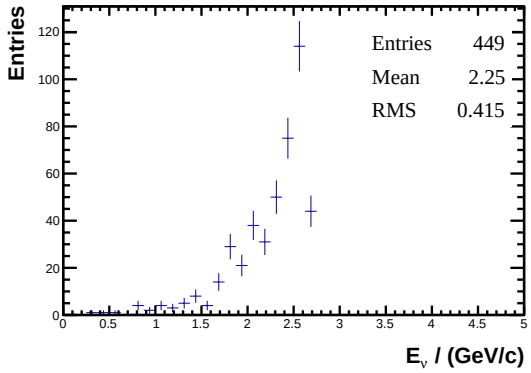
$L_b \to p\mu\nu$ line	Rate (%)	Accepted	ms/evt
Above cuts	0.449	449	0.474
2000 MeV/c^2 $\leq M_{p\mu}$	0.246	246	0.386

- Require rate $< 0.5\%$ and timing < 0.5 ms/evt.

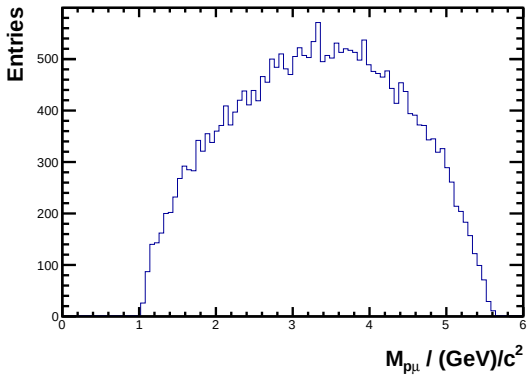
$M_{p\mu}$ and E_ν Distributions

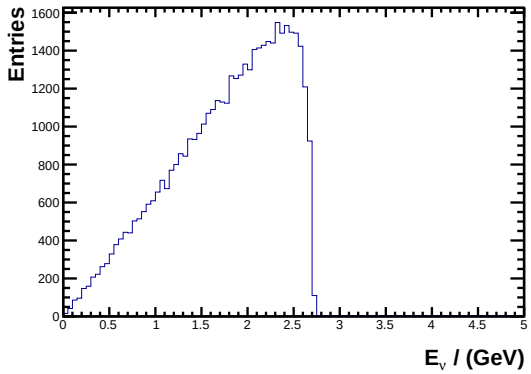
$M_{p\mu}$ and E_ν Distributions using 2012 test data



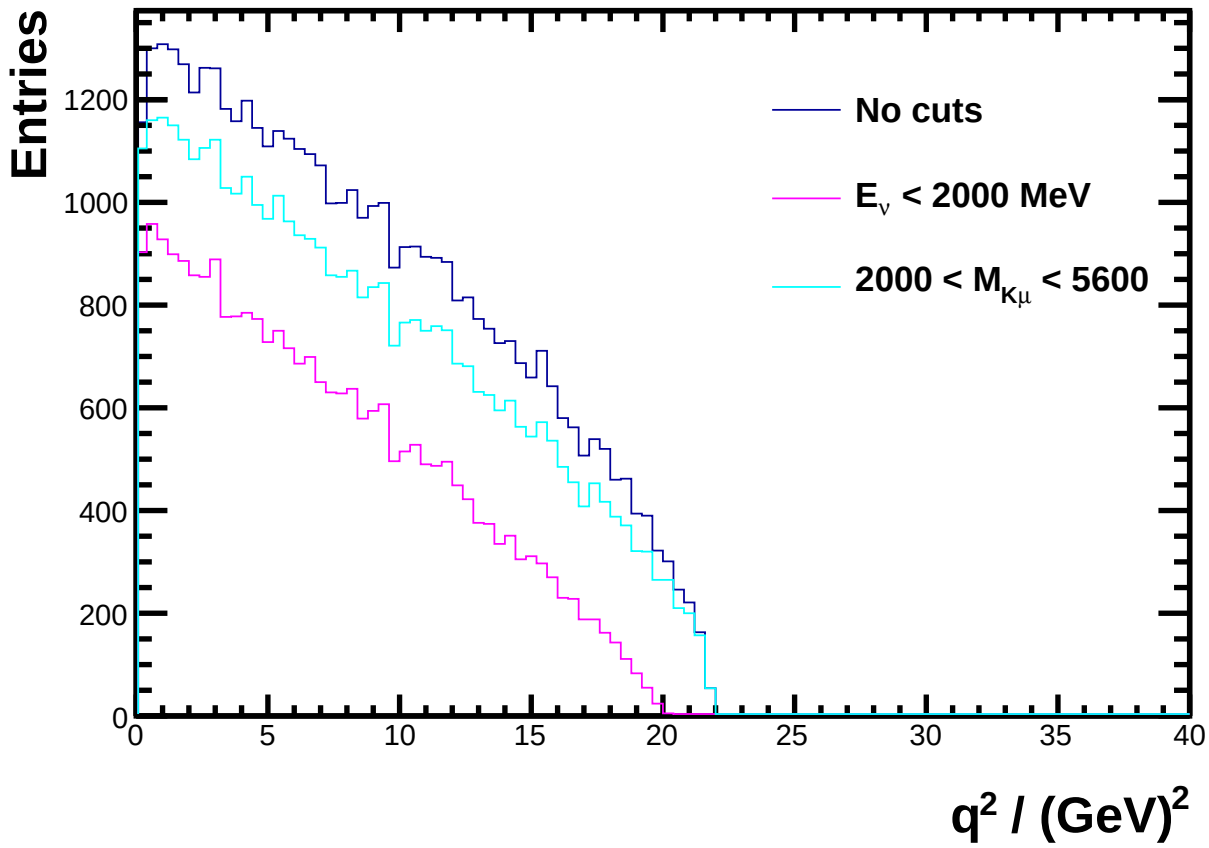


$M_{p\mu}$ and E_ν Distributions for generator level $\Lambda_b \to p\mu\nu$





$\Lambda_b \to p\mu\nu$ generator level q^2 distribution



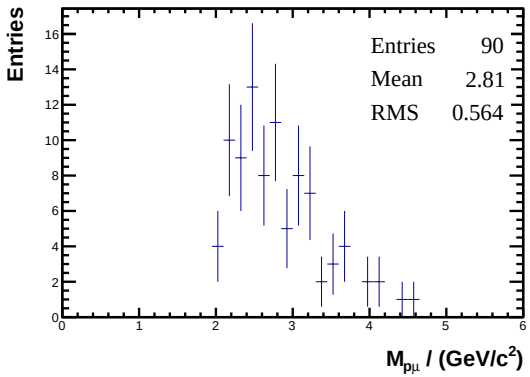
$\Lambda_b \to p\mu\nu$ Line: Tightened Selection

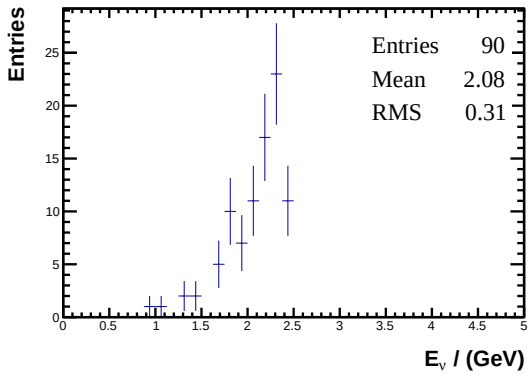
Proton cuts	Muon cuts	Mother cuts
$P > 15000$ MeV/c	$P > 3000$ MeV/c	$cos\theta_{B_s(p\mu)} > 0.999$
$p_T > 1000 MeV/c$	$p_T > 1400 MeV/c$	IP $\chi^2 > 16.0$
Track $\chi^2 < 6.0$	Track $\chi^2 < 4.0$	Vertex $\chi^2 < 3.0$
Min IP $\chi^2 > 16.0$	Min IP $\chi^2 > 12.0$	χ^2 sep. from PV > 100.0
$\Delta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

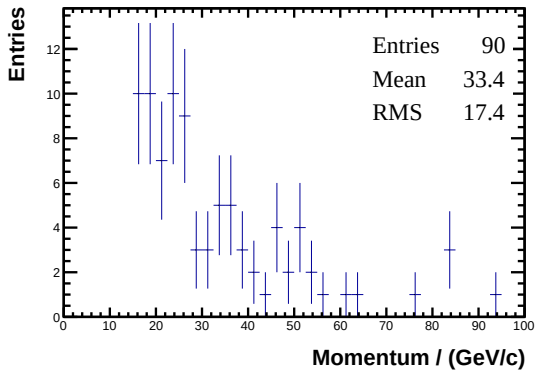
- StdLooseMuons and StdLooseKaons selections.
- L0Muon, Hlt2SingleMuon, Hlt2TopoMu2Body
- Track Ghost probability < 0.5
- Combination cut: $2000 MeV/c^2 \leq M_{p\mu} \leq 5500 MeV/c^2$ and $p_{T(p\mu)} > 1500$MeV/c.

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

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







Conclusion

- $\Lambda_b \to p\mu\nu$ is a promising channel for an exclusive measurement of V_{ub}.