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


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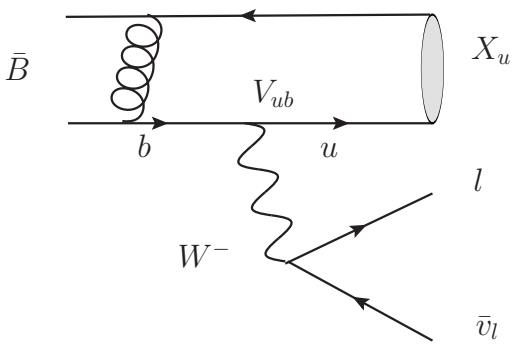
March 19, 2013

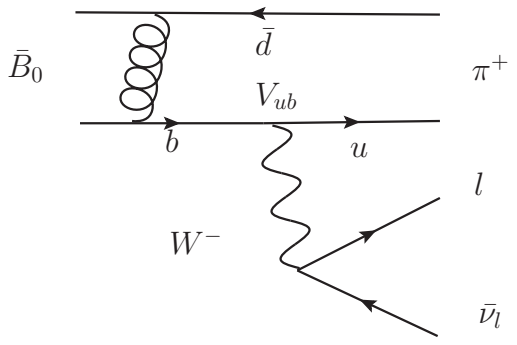
# Current Status of $|V_{ub}|$

- Semi-Leptonic B Decays:

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

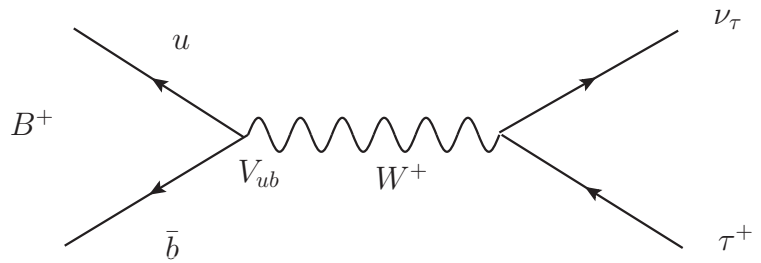



Exclusive ($\bar{B}_0 \to \pi^+ l \bar{\nu}_l$)

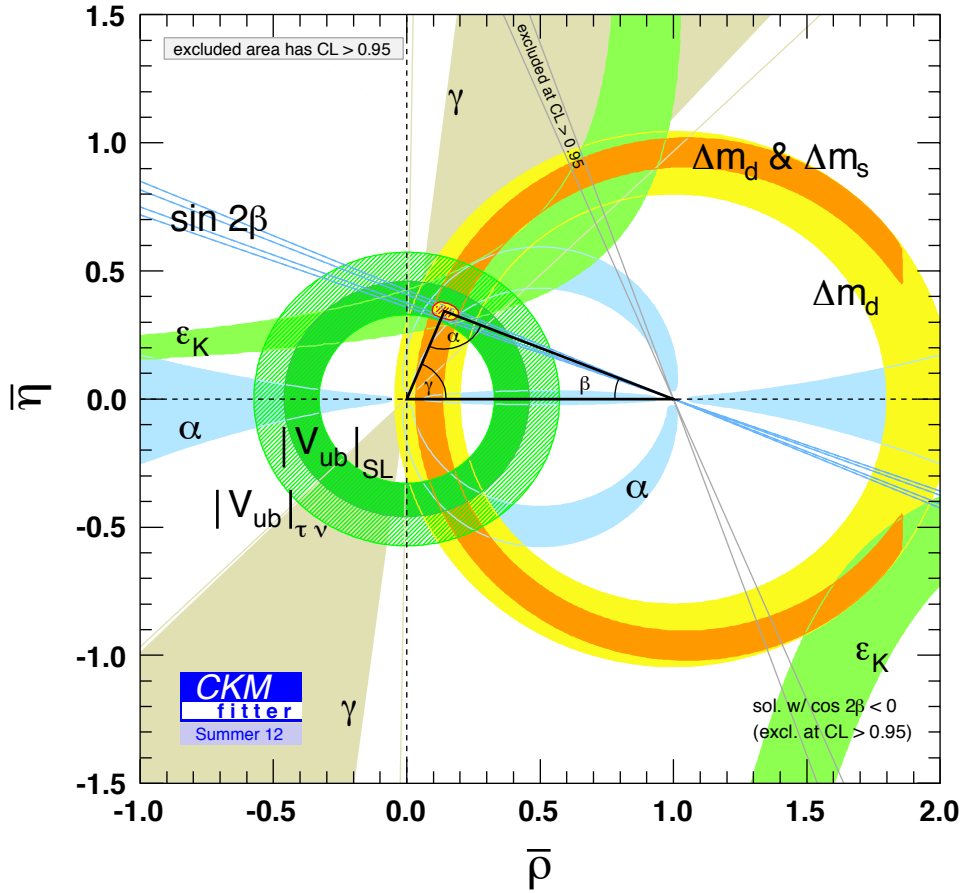



$|V_{ub}| = (4.41 \pm 0.15^{+0.15}_{-0.17}) \times 10^{-3}$ $|V_{ub}| = (3.23 \pm 0.31) \times 10^{-3}$

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



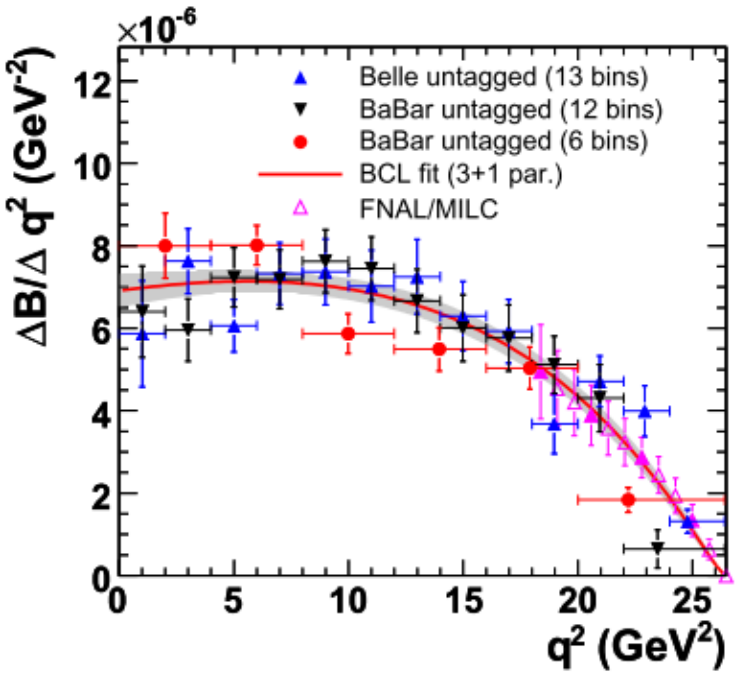
# $|V_{ub}|$ Constraints on the Unitarity Triangle



# 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 $|f_+(q^2)|^2$.

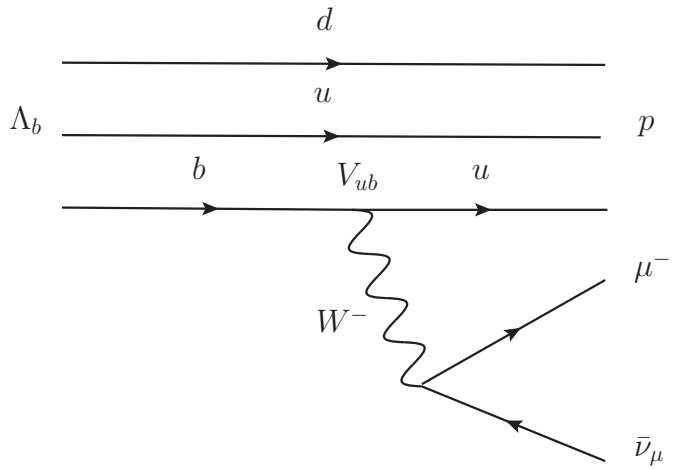
Measured partial branching fraction $\Delta B(\bar{B}_0 \to \pi^+ l^- \bar{\nu}_l)$ [2]:




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

# $|V_{ub}|$ with LHCb

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



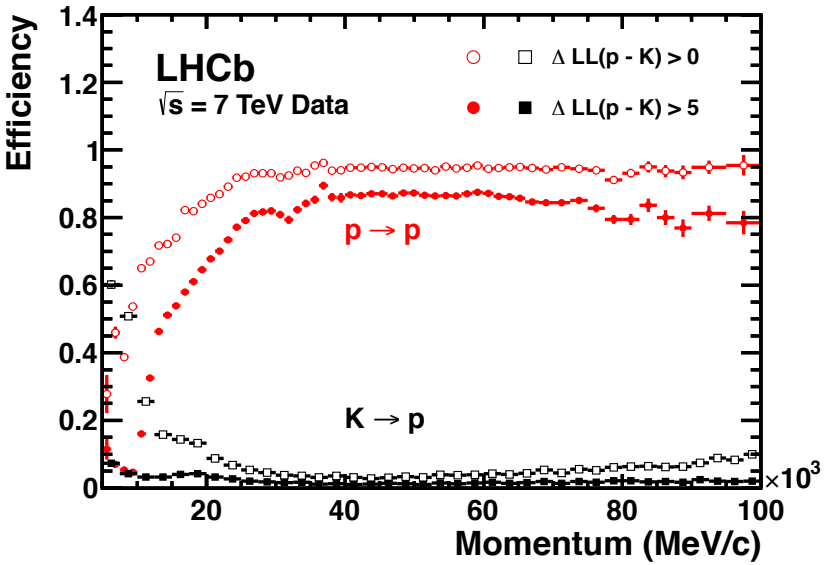

- Advantages of $\Lambda_b \to p\mu^-\bar{\nu}_\mu$:
  - $f_{\Lambda_b}/(f_u + f_d) \sim 0.40$ and $f_{\Lambda_b}/f_s \sim 3$
  - Proton provides a more distinctive final-state.

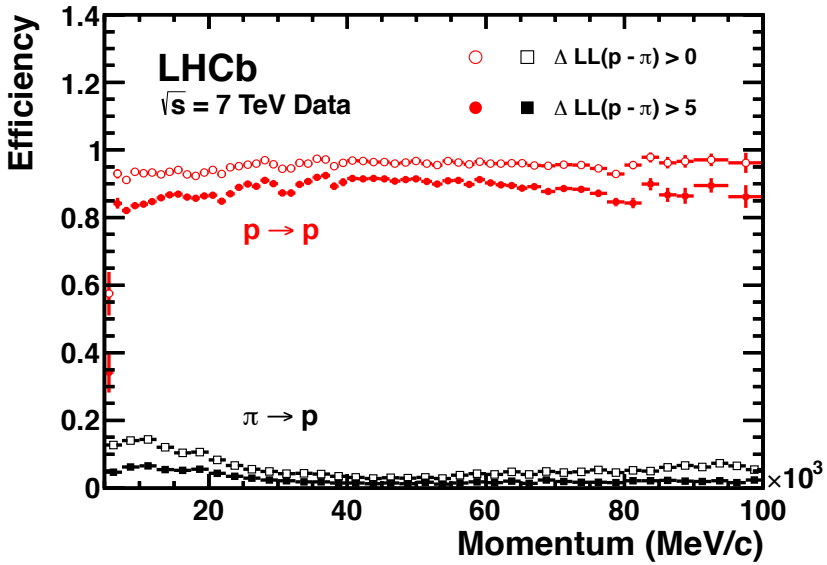
# Current $B_s \to K\mu\nu$ Stripping Selection

| Kaon cuts | Muon cuts | Mother cuts |
|---|---|---|
| $P > 3000$ MeV/c | $P > 3000$ MeV/c | $cos\theta_{B_s Y} > 0.99$ |
| $p_T > 800 MeV/c$ | $p_T > 800 MeV/c$ | $E_\nu < 2000$MeV |
| Track $\chi^2 < 6.0$ | Track $\chi^2 < 4.0$ | Vertex $\chi^2 < 2.0$ |
| Min IP $\chi^2 > 16.0$ | Min IP $\chi^2 > 12.0$ | $\chi^2$ 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

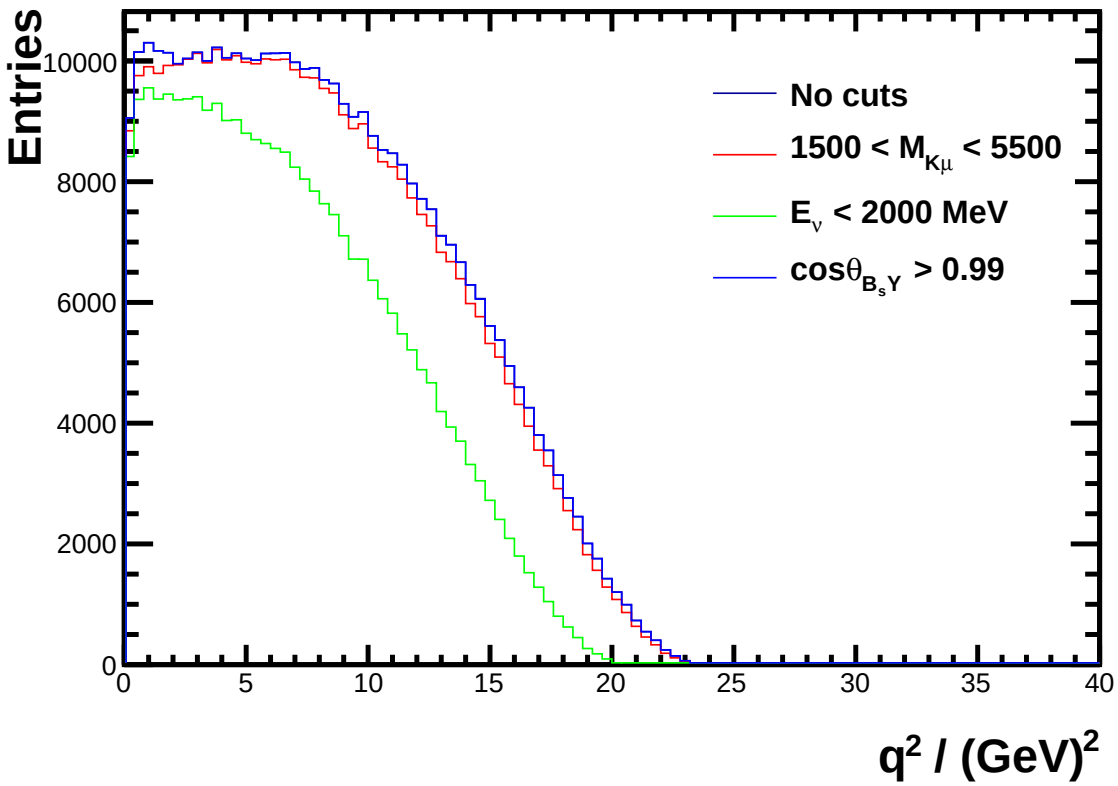
- No available $\Lambda_b \to p\mu\nu$ MC sample yet.
- Strip $B_s \to K\mu\nu$ 2011 MC sample using existing line + $P_K > 10$ GeV/c.
- Signal Efficiency for stripping: $7.2 \pm 0.1\%$.
- Acceptance, $A \approx 1.4\%$.
- In 1 fb$^{-1}$ expect:
  $N_{Events} = 2 \times \sigma(b\bar{b}) \times f_{\Lambda_b}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

  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

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

# $B_s \to K\mu\nu$ MC

- Remove certain cuts to investigate their impact.
- $E_\nu$ cut kills the endpoint of the $q^2$ distribution.



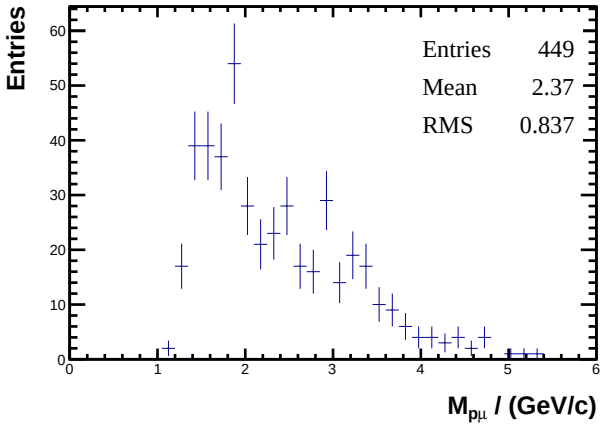
# $\Lambda_b \to p\mu\nu$ Line

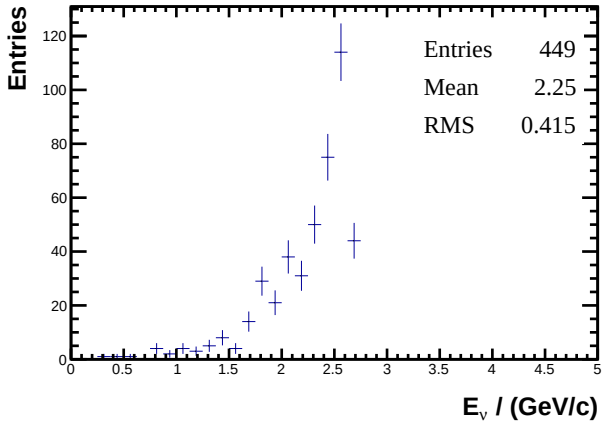
- $\Lambda_b \to p\mu\nu$ stripping line based on the current $B_s \to K\mu\nu$ line.
- Remove $E_\nu$ cut. Demand $P_{proton} > 15$ GeV/c and 1000 MeV/c$^2$ $\leq M_{p\mu} \leq$ 5600 MeV/c$^2$.
- Test using TestMyStrippingLineOn2012Data_Reco14.py script (100,000 events):

| $L_b \to p\mu\nu$ 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 |

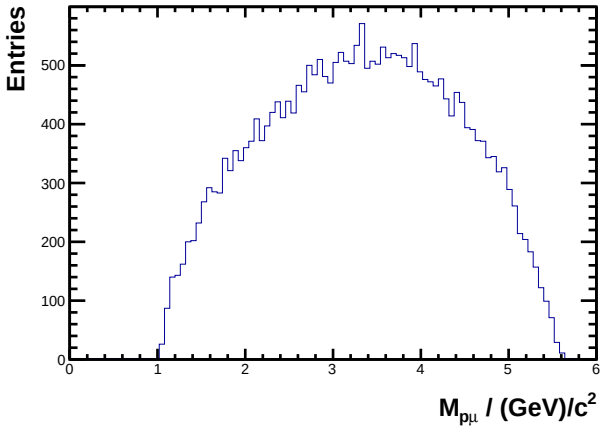
- Require rate $< 0.5\%$ and timing $< 0.5$ ms/evt.

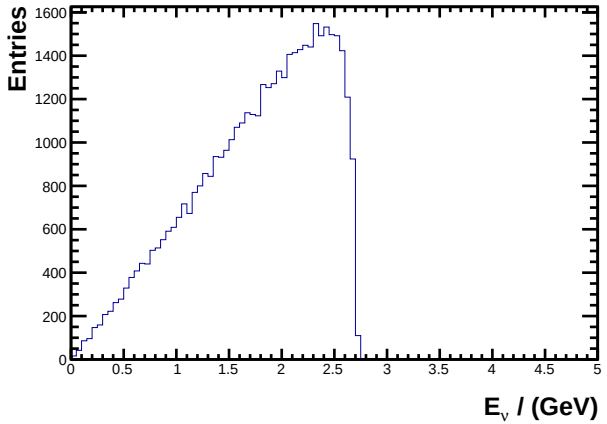
# $M_{p\mu}$ and $E_\nu$ Distributions using 2012 test data



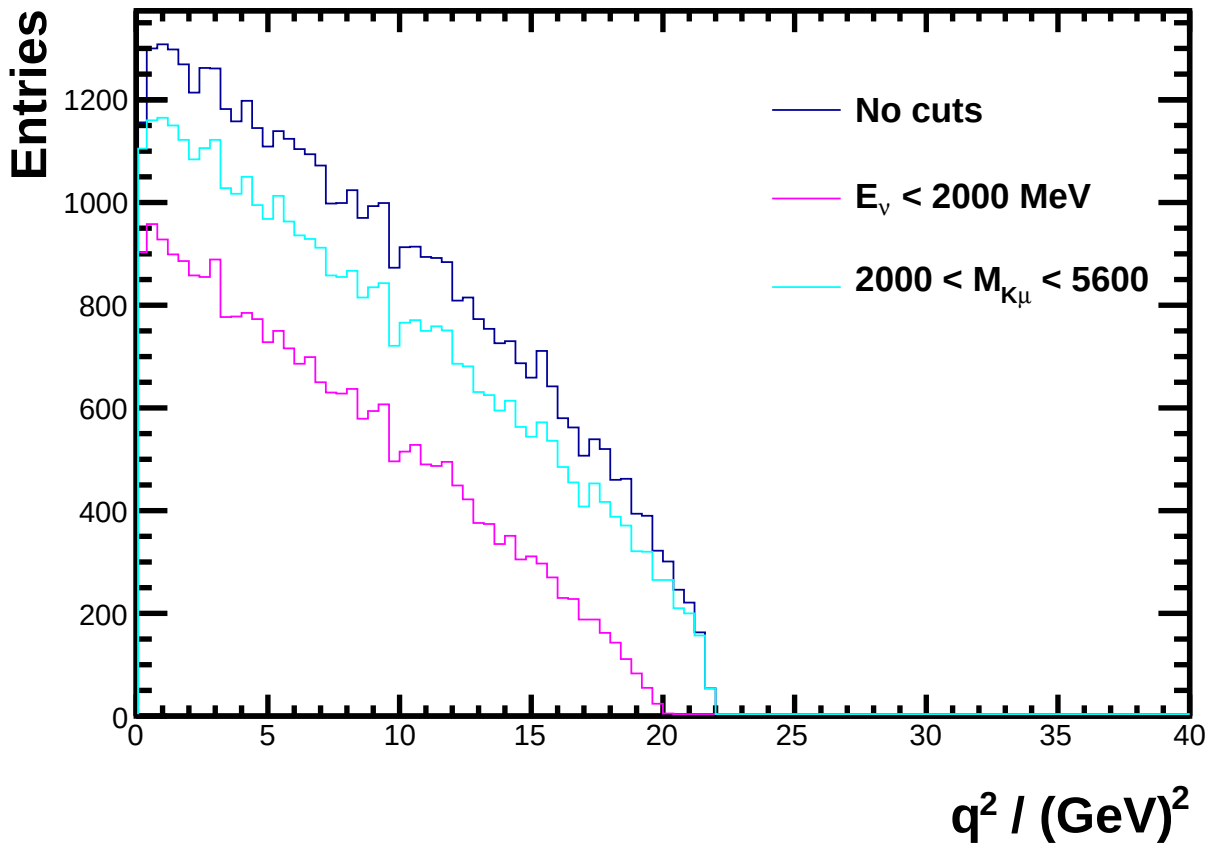




# $M_{p\mu}$ and $E_\nu$ Distributions for generator level $\Lambda_b \to p\mu\nu$



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



# Conclusion

- $E_\nu$ cut kills the $q^2$ endpoint.
- Additional cuts required to reduce rate to 0.5%.