

ASYMMETRY IN Λ_b AND $\bar{\Lambda}_b$ PRODUCTION 1/6

J. Rosner – Heavy-Quark Baryon Workshop – July 24, 2014

PR D **90**, 014023 (2014) [arXiv:1405.2885]

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Motivated by A_{FB} in $p\bar{p} \rightarrow t\bar{t}$ being possibly larger than in SM

In CMS data at LHC, $\sigma(pp \rightarrow \bar{\Lambda}_b X) / \sigma(pp \rightarrow \Lambda_b X)$ appears to fall as baryons become more forward

Exploring a couple of mechanisms which could give this effect

ATLAS, LHCb, and Tevatron detectors: search for similar effect

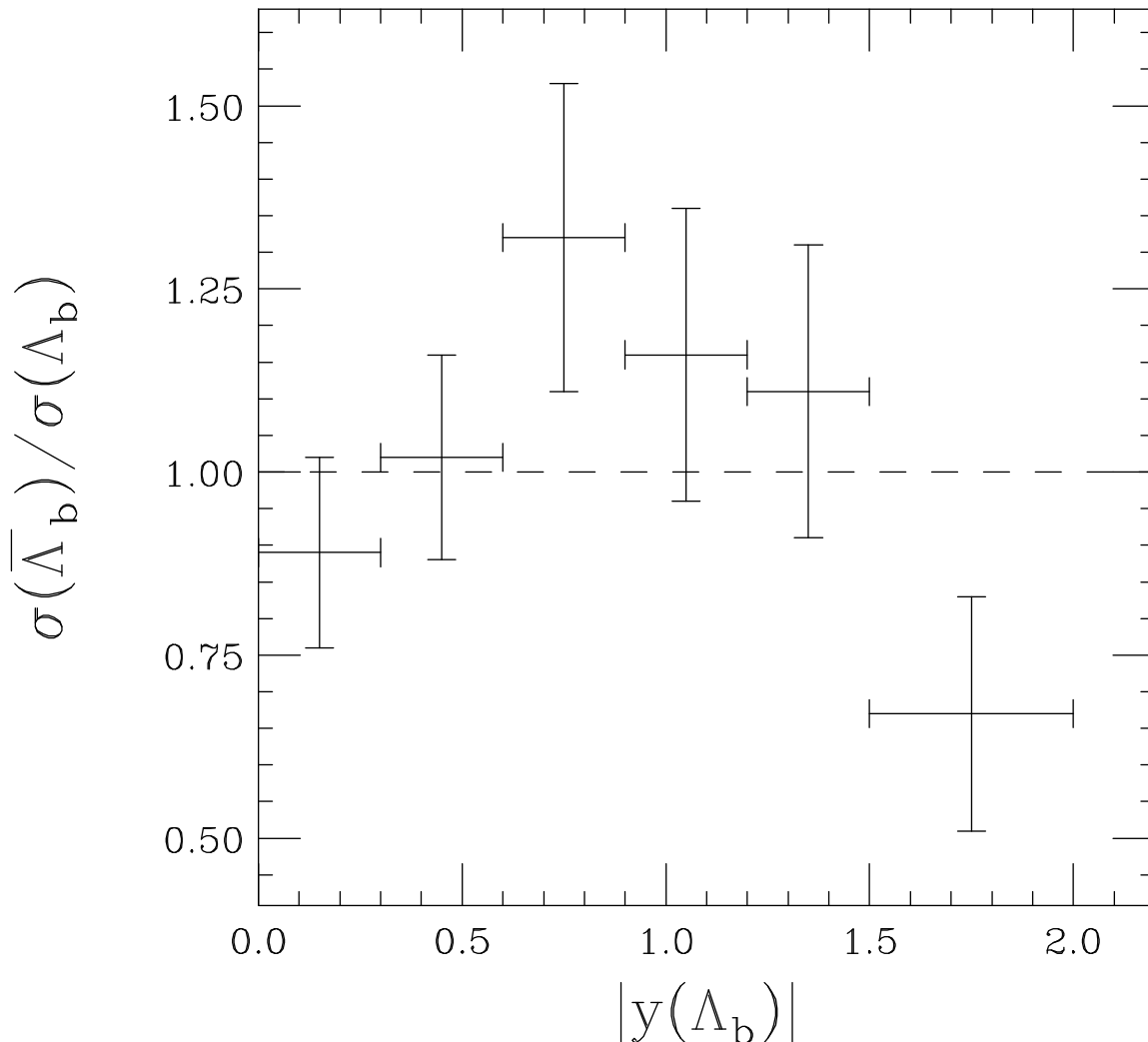
At Tevatron, Λ_b would tend to follow proton and $\bar{\Lambda}_b$ would tend to follow antiproton. Eliminates particle vs. antiparticle bias.

At ISR, Λ_c production favored over that of $\bar{\Lambda}_c$: Nonperturbative!

ASYMMETRIES?

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At $\sqrt{s} = 7$ TeV LHCb finds $A_P \equiv [\sigma(D_s^+) - \sigma(D_s^-)]/[\sigma(D_s^+) + \sigma(D_s^-)] = (-0.33 \pm 0.22 \pm 0.10)\%$ for $2.0 \leq y \leq 4.5$: No leading-quark effect.



⇐ CMS at LHC (1.96 fb^{-1} at $\sqrt{s} = 7$ TeV: Not claiming significant variation with $|y(\Lambda_b)|$ but most-forward bin is about 2/3

Is this behavior observed at higher $|y(\Lambda_b)|$?

PRODUCTION MECHANISMS

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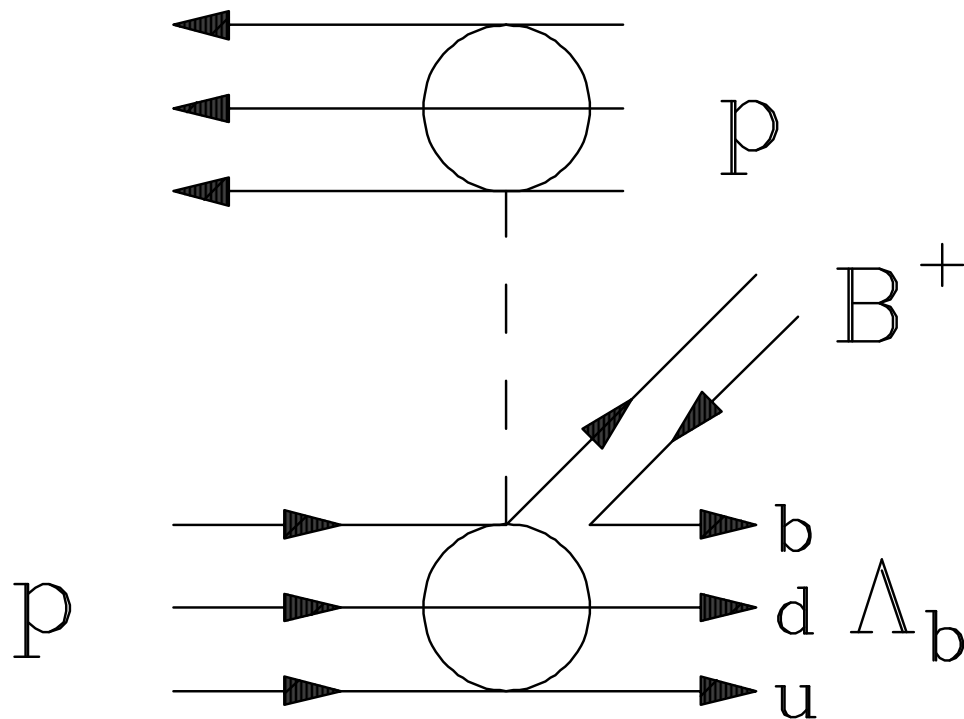
Mechanisms without asymmetry

$q\bar{q} \rightarrow b\bar{b}$ and $gg \rightarrow b\bar{b}$ have no asymmetry in lowest order

Expected to dominate at small y and large p_T

Some additional contribution needed for Λ_b production at small p_T

Quasi-diffractive excitation



Would favor Λ_b production
by protons and $\bar{\Lambda}_b$
production by antiprotons

Some features in common with
intrinsic heavy quark picture

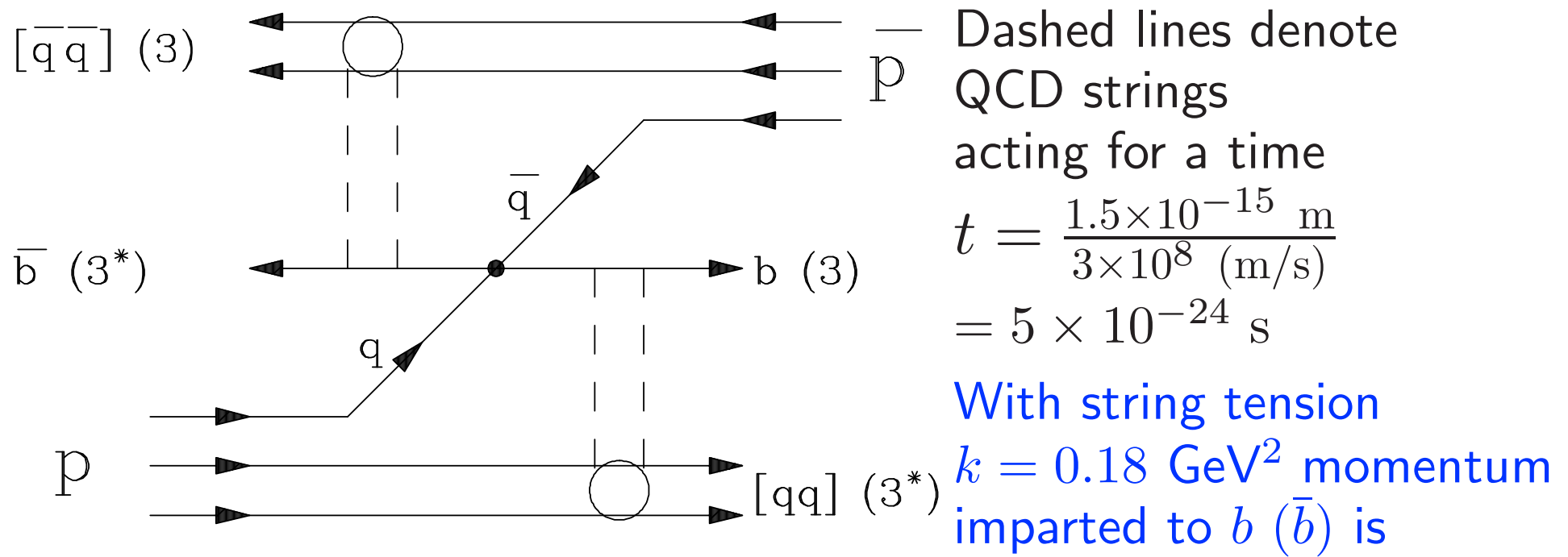
Heavy forward baryon more
likely to contain a b than a \bar{b}

INTERACTION WITH SPECTATOR QUARK 4/6

String-drag model: JLR, PR D **86**, 014011 (2012)

QCD string breaks at length of 1.5 fm [PL B **396**, 293 (1996)]

Interaction of final heavy quarks with spectators (for initial $p\bar{p}$):



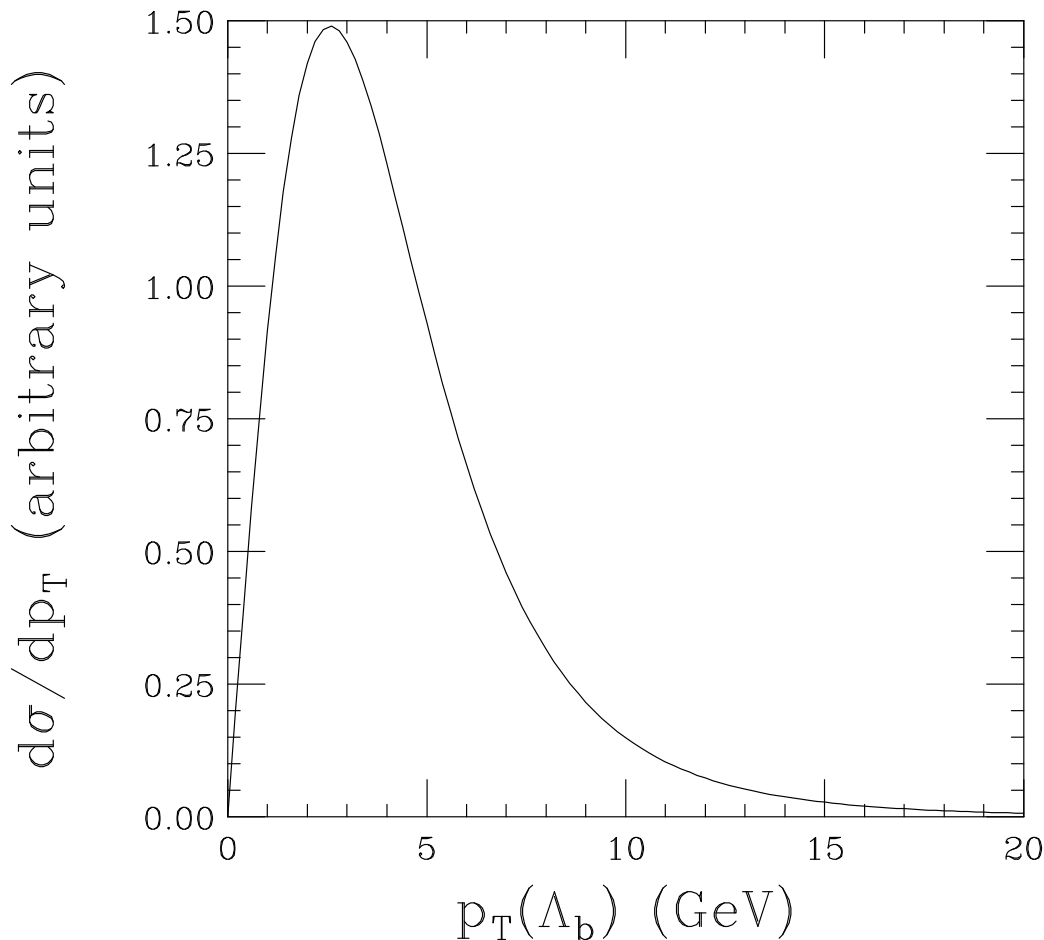
$$\Delta p_z = kt = \frac{(0.18 \text{ GeV}^2)(5 \times 10^{-24} \text{ s})}{6.582 \times 10^{-25} \text{ GeV} \cdot \text{s}} \simeq 1.4 \text{ GeV}$$

pulling b quark in direction of proton

EFFECT OF STRING DRAG

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As $\langle p_T \rangle$ of Λ_b is about 5 GeV in CMS this is non-negligible
“Tsallis” distribution [J. Stat. Phys. **52**, 479 (1988)]:



Let θ be b polar angle;
 $y = -\ln \tan(\theta/2)$;
 $dy/d\theta = -\text{cosh } y$
 $= -1$ at $y = 0$

$$\Delta\theta \simeq -\Delta p_z/p_T$$

Hence at $y = 0$

$$\Delta y = -\Delta\theta \simeq 1.4 \text{ GeV}/p_T$$

Independent of y

About $3 \times$ hep-ph/0002056

CONCLUSIONS

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Monte Carlo programs should include interactions of final-state heavy quarks with remnant (“spectator”) systems

Apparently some programs do this, e.g., P. Skands *et al.*, J. High Energy Phys. 07 (2012) 151 [arXiv:1205.1466 [hep-ph]]

String drag unimportant for top production but worth considering for b

Λ_b production asymmetry is an interesting measurement!

As a CDF member I hope to analyze it in our data.