BEAUTY BARYON PRODUCTION IN P-P COLLISIONS AT LHC AND b-QUARK DISTRIBUTION IN PROTON

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Forward production of beauty and charmed baryons in $p-p$ collisions at LHC

$pp \to \Lambda_b(\Lambda_c)X$
$pp \to \Lambda_b(\Lambda_c)B(D)X$
For the Λ_b production after its decay
$\Lambda_b \to J/\psi\ \Lambda^0$
$J/\psi \to \mu^+\mu^-(e^+e^-)$ and $\Lambda^0 \to p\pi^-$
the final hadrons are the following:
$pp \to \mu^+\mu^-(e^+e^-)\ p\pi^-\ X$

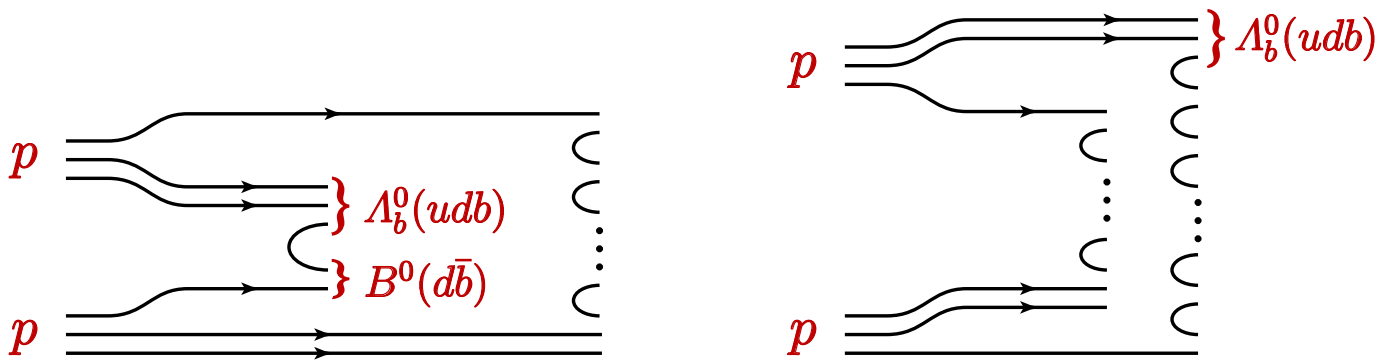


Figure 1: Graphs for heavy meson production in the semi-inclusive $pp \to \Lambda_b^0 B^0 X$ reaction (left) and in the inclusive $pp \to \Lambda_b^0 X$ process (right).

Dual parton model (DPM) or Quark-gluon string model (QGSM)

*A.Capella, U.Sukhatme, C.I.Tan, J.Tran Than Van, Phys.Lett., B***81**, *68 (1979); ibid Phys.Rep.,* **236** *223 (1994); A.B.Kaidalov, K.A.Ter-Martirosyan, Phys.Lett., B***117**, *247 (1982).*

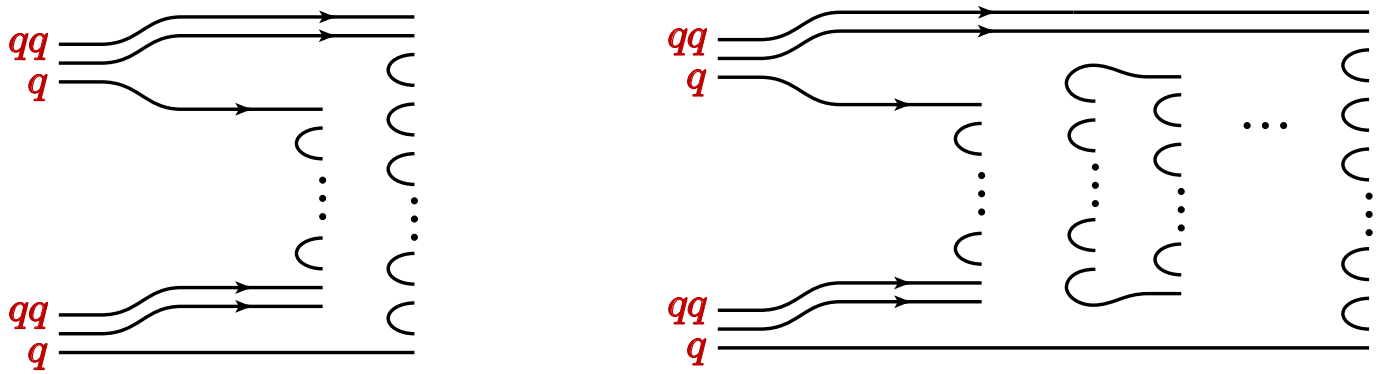


Figure 2: The one-cylinder graph (left diagram) and the multi-cylinder graph (right diagram) for the inclusive $pp \to hX$ process.

$$\rho(x)^{pp} \equiv \int d^2p_t \frac{d\sigma^{pp}}{d^3p} = \sum_{n=1}^{\infty} \sigma_n(s)\phi_n^{pp}(x) \ ,$$

$$\phi_n^{pp}(x) = F_{qq}^{(n)}(x_+)F_{q_v}^{(n)}(x_-) + F_{q_v}^{(n)}(x_+)F_{qq}^{(n)}(x_-) + 2(n-1)F_{q_s}^{(n)}(x_+)F_{\bar{q}_s}^{(n)}(x_-) \ .$$

Captions

$x_\pm = 0.5(\sqrt{x^2 + x_t^2} \pm x)$,

$$F_\tau^{(n)}(x_\pm) = \int_{x_\pm}^1 dx_1 f_\tau^{(n)}(x_1) G_{\tau\to h}\left(\frac{x_\pm}{x_1}\right) ,$$

Here τ means the flavor of the valence (or sea) quark or diquark, $f_\tau^{(n)}(x_1)$ is the quark distribution function depending on the longitudinal momentum fraction x_1 in the n-Pomeron chain; $G_{\tau\to h}(z) = zD_{\tau\to h}(z)$, $D_{\tau\to h}(z)$ is the fragmentation function of a quark (antiquark) or diquark of flavor τ into a hadron h (charmed hadron in our case); σ_n is the cross section for production of the n-Pomeron chain (or $2n$ quark-antiquark strings) decaying into hadrons, calculated within the "eikonal approximation"

*K.A.Ter-Martirosyan Phys.Lett., B***44**, *377(1974).*

Quark distributions of see b quarks in proton

$$f_{b(\bar b)}^{n)}(x) = C_{b(\bar b)}^{(n)} \delta_{b(\bar b)} x^{-\alpha_\Upsilon(0)} (1-x)^{\alpha_\rho(0) - 2\alpha_B(0) + (\alpha_\rho(0) - \alpha_\Upsilon(0)) + n - 1} ,$$

where $\alpha_\rho(0) = 1/2$ is the intercept of the ρ-trajectory; $\alpha_B(0) \simeq -0.5$ is the intercept of the baryon trajectory, $\alpha_\Upsilon(0) = 0(-8, -16)$ is the intercept of the Υ- Regge trajectory.

Quark distributions of see c quarks in proton

$$f_{c(\bar c)}^{n)}(x) = C_{c(\bar c)}^{(n)} \delta_{c(\bar c)} x^{-\alpha_\psi(0)} (1-x)^{\alpha_\rho(0) - 2\alpha_B(0) + (\alpha_\rho(0) - \alpha_\psi(0)) + n - 1} ,$$

where $\alpha_\psi(0) = 0(-2.18)$ is the intercept of the ψ- Regge trajectory.

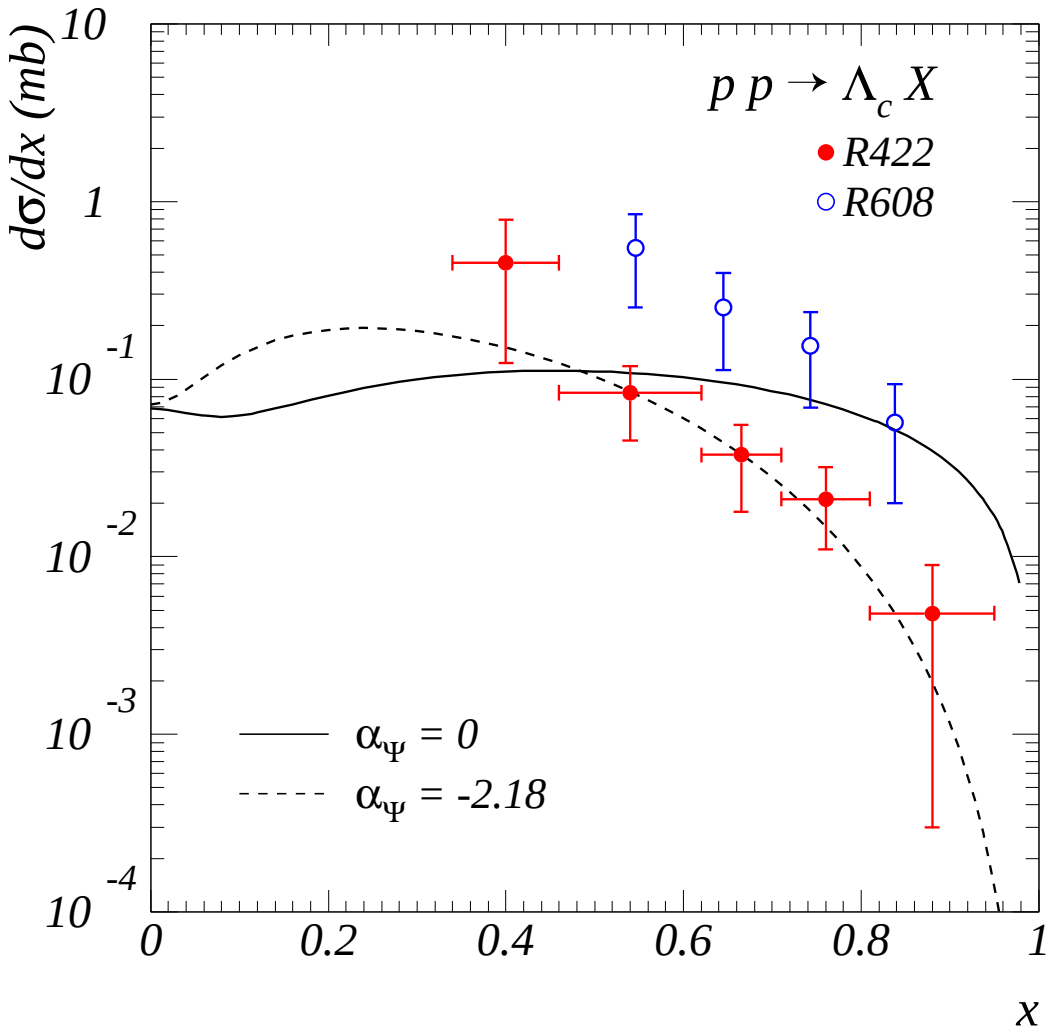


Figure 3: The differential cross section $d\sigma/dx$ for the inclusive process $pp \to \Lambda_c X$ at $\sqrt{s} = 62$ GeV. Experimental data:red points (R422) – G.Bari,*et al.*, Nuovo Cim. A**104**, 571(1991); open blue circles (R608) – P.Chauvat,*et al.*, Phys. Lett. B**199**, 304(1987)

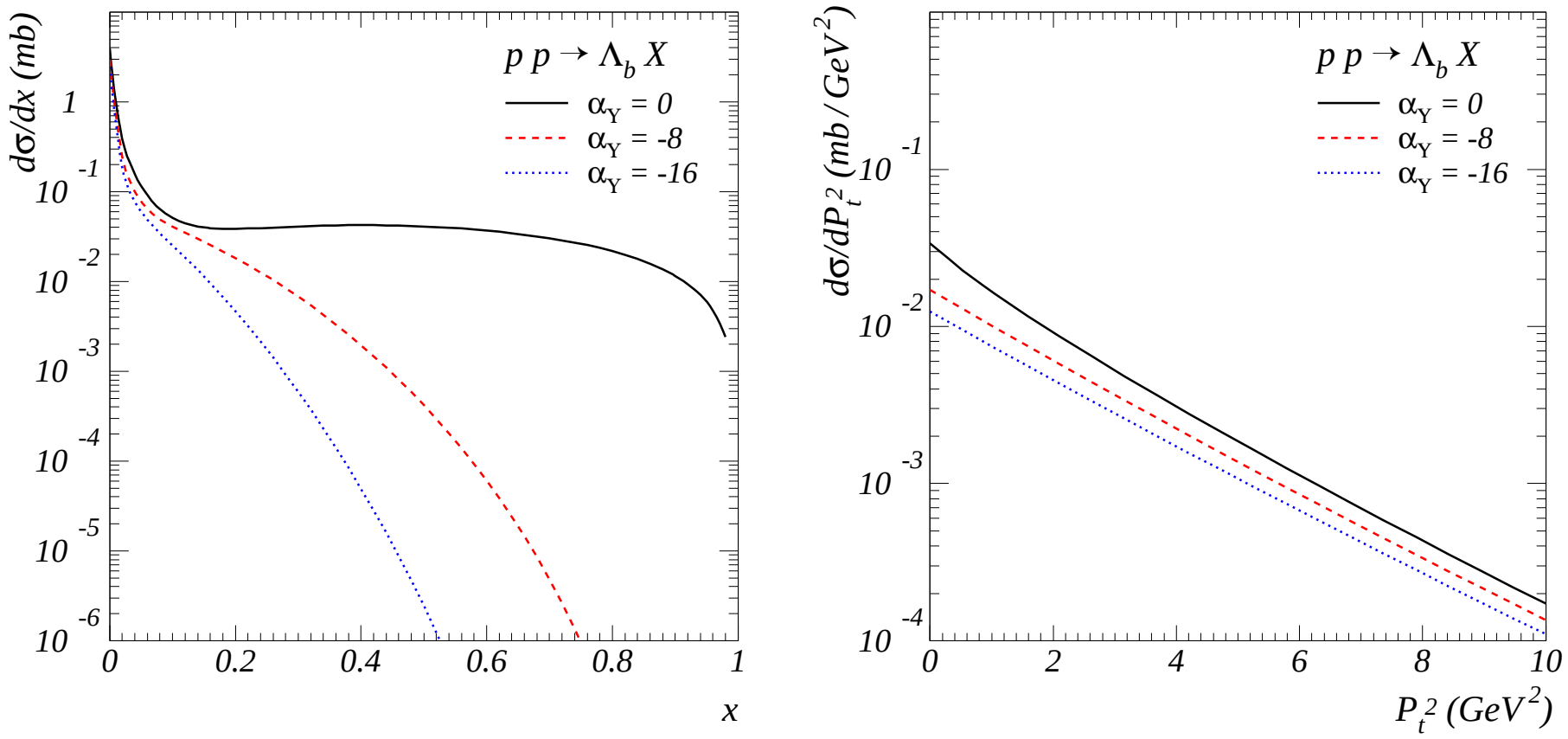
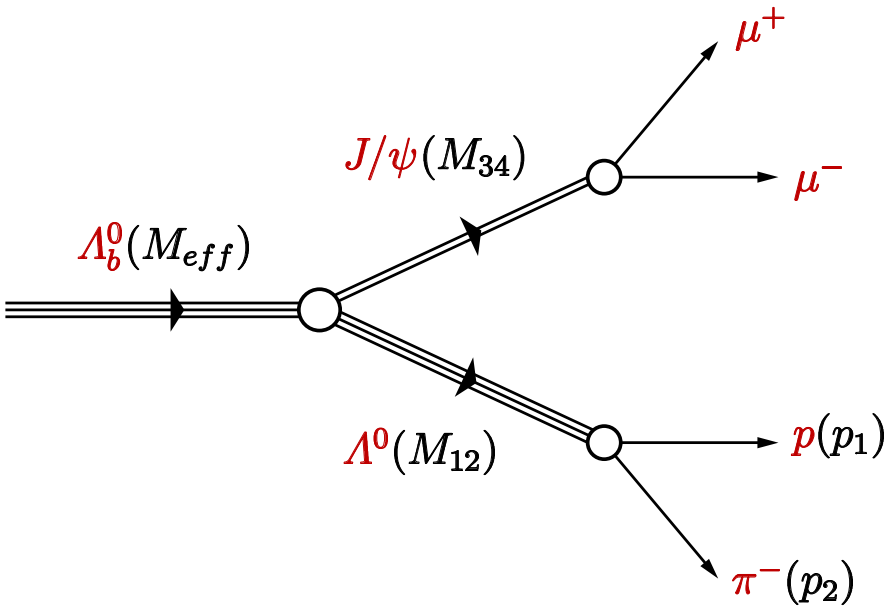


Figure 4: The differential cross section $d\sigma/dx$ (left) and $d\sigma/dP_t^2$ (right) for the inclusive process $pp \to \Lambda_b X$ at $\sqrt{s} = 4$ TeV.

There are the experimental data on the Λ_b production in $p\bar{p}$ collision and its decay $\Lambda_b \to J/\psi\ \Lambda^0$ obtained at the Tevatron. *F.Abe. et al., Phys.Rev. D***55**, *1142 (1997).*
$f_{b(\bar{b}}(x) \sim\ (1-x)^2$ when $\alpha_\Upsilon(0) = 0$, $f_{b(\bar{b}}(x) \sim x^{-8}(1-x)^{10}$ when $\alpha_\Upsilon(0) = -8$ and
$f_{b(\bar{b}}(x) \sim x^{-16}(1-x)^{18}$ when $\alpha_\Upsilon(0) = -16$.

Forward Λ_b production in $p-p$ at LHC and its decay



$pp \to \Lambda_b \to J/\Psi\ \Lambda^0 \to \mu^+\mu^-\ p\pi$

$$\frac{d\sigma}{d^3p_1 dM_{34}} = \int \frac{d\sigma}{dM_{12}dM_{34}}\delta^{(3)}(\mathbf{p}_1+\mathbf{p}_2-\mathbf{p}_{12})dM_{12}\ ,$$

where

$$\frac{d\sigma}{dM_{12}dM_{34}} = \int d^2p_{t\Lambda_b}\frac{d\sigma_{pp\to\Lambda_b X}}{dx d^2p_{t\Lambda_b}} Br_{\Lambda_b\to J/\Psi} Br_{J/\Psi\to\mu^+\mu_-} Br_{\Lambda^0\to p\pi}\frac{\pi^3}{2M_{eff}^2 M_{12}M_{34}}$$
$$\lambda^{1/2}(M_{eff}^2,M_{12}^2,M_{34}^2)\lambda^{1/2}(M_{12}^2,M_1^2,M_2^2)\lambda^{1/2}(M_{34}^2,M_3^2,M_4^2)\ ,$$

$Br_{\Lambda_b\to J/\Psi} = (4.7\pm 2.8)\cdot 10^{-4}$; $Br_{J/\Psi\to\mu^+\mu_-} = (5.93\pm 0.06)\%$; $Br_{\Lambda^0\to p\pi} = 63.9\pm 0.5)\%$.

Here $\lambda(x^2,y^2,z^2) = ((x^2-(y+z)^2)((x^2-(y-z)^2)$

Forward Λ_b production in $p-p$ at LHC and its decay

One can get the following relation

$$d^3p_1 \;=\; \frac{1}{2}p\xi_p d\phi_1 d\xi_p dt_p \;,$$

where $\xi_p = \Delta p/p$ is the energy loss, $t_p = (p_{in} - p_1)^2$, ϕ_1 is the azimuthal angle of the final proton p_1. Experimentally one can measure the differential cross section

$$\frac{d\sigma}{d\xi_p dt_p dM_{J/\Psi}} \;=\; \frac{1}{2}p\xi_p \int \frac{d\sigma}{d^3p_1 dM_{34}} d\phi_1$$

Background from beauty baryon resonances and other b-baryons decaying into $\Lambda_b\pi$

$\Sigma_b^*(5.83) \to \Lambda_b\pi, \Sigma_b(5.81) \to \Lambda_b\pi$**, etc.**

$$x\frac{d\sigma_{pp\to\Lambda_b X}}{dx} = x\frac{d\sigma^{direct}_{pp\to\Lambda_b X}}{dx} + \sum_{B_i}\int_{x^*_-}^{x^*_+} x_i \frac{d\sigma_{pp\to B_i X}}{dx_i}\Phi(x_i)dx_i \;,$$

where $x^*_\pm = M_{B_i}\tilde{x}/(E^* \mp p^*)$ and $\tilde{x} = \sqrt{x^2 + x_t^2}, x_t = 2\sqrt{< p_t^2 > + m^2}/\sqrt{s}$

(*G.L., G.H.Arakelyan, M.N.Sergeenko, Phys.Part.Nucl.,* **30**,*343 (1999)*)

SUMMARY

I. The DPM or QGSM can be applied to study the heavy baryon production in $p-p$ collisions at high energies.

II. The inclusive spectra of charmed and especially beauty baryons are very sensitive to the values of the heavy meson Regge trajectories.

III. It allows us to extract a new information on the beauty and charmed quark distributions in proton from the analysis of these spectra.

IV. Some predictions for the future experiments at LHC on the Λ_b production in $p-p$ collision are presented.

V. A proposal for the forward experiments at LHC on the reaction $pp \to \Lambda_b X \to J/\psi\ \Lambda^0 X \to \mu^+\mu^- p\pi^- X$ is presented.

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