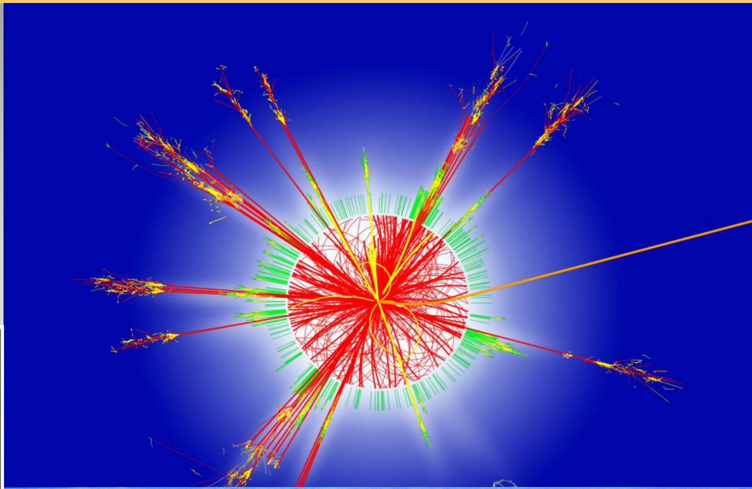
Forward production of charmed and bottom hadrons in pp collisions and intrinsic beauty in proton

Gennady Lykasov

in collaboration with D.A.Artemenkov and V.A.Bednyakov

Joint Institute for Nuclear Research, Dubna, Russia



OUTLINE

I. Forward production of beauty and charmed baryons in p-p collisions

II. Quark-gluon string model and heavy baryon production in p-p collisions

III. Forward Λ_b production in p-p at LHC and its decay

IV. Predictions for the LHC experiments. Intrinsic charm and beauty in proton

V. Summary

Forward production of heavy baryons in p-p collisions

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

$$\Lambda_b \to J/\psi \, \Lambda^0$$

$$J/\psi \to \mu^+ \mu^- (e^+ e^-) \quad \text{and} \quad \Lambda^0 \to p \pi$$

the final hadrons are the following:

$$pp \to \mu^+ \mu^- (e^+ e^-) p \pi^- X$$

Dual parton model or Quark-gluon string model

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

A.Capella, U.Sukhatme, C.I.Tan, J.Tran Than Van, Phys.Lett., B81, 68 (1979); ibid Phys.Rep., **236** 223 (1994); A.B.Kaidalov, K.A.Ter-Martirosyan, Phys.Lett., **B117,** 247 (1982).

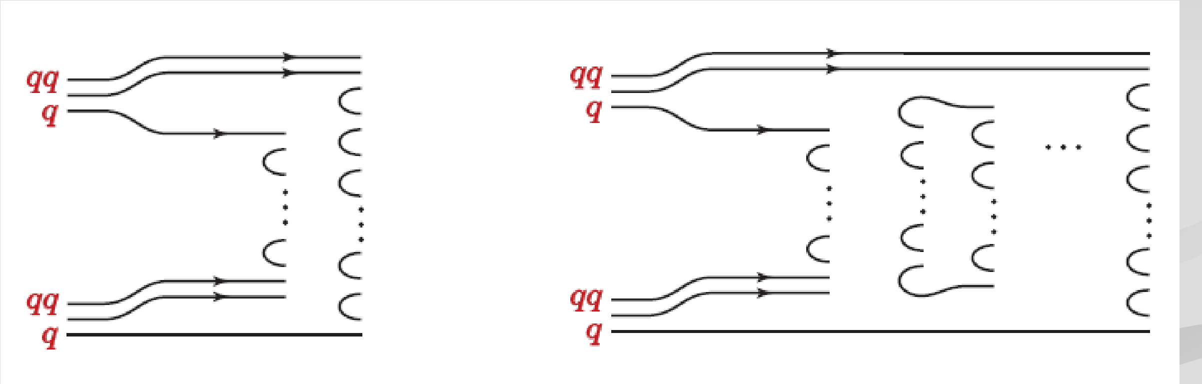


Figure 1: The one-cylinder graph (left diagram) and the multi-cylinder graph (right diagram) for the inclusive pp→hX process.

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

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

Charmed baryon production in p-p within the QGSM

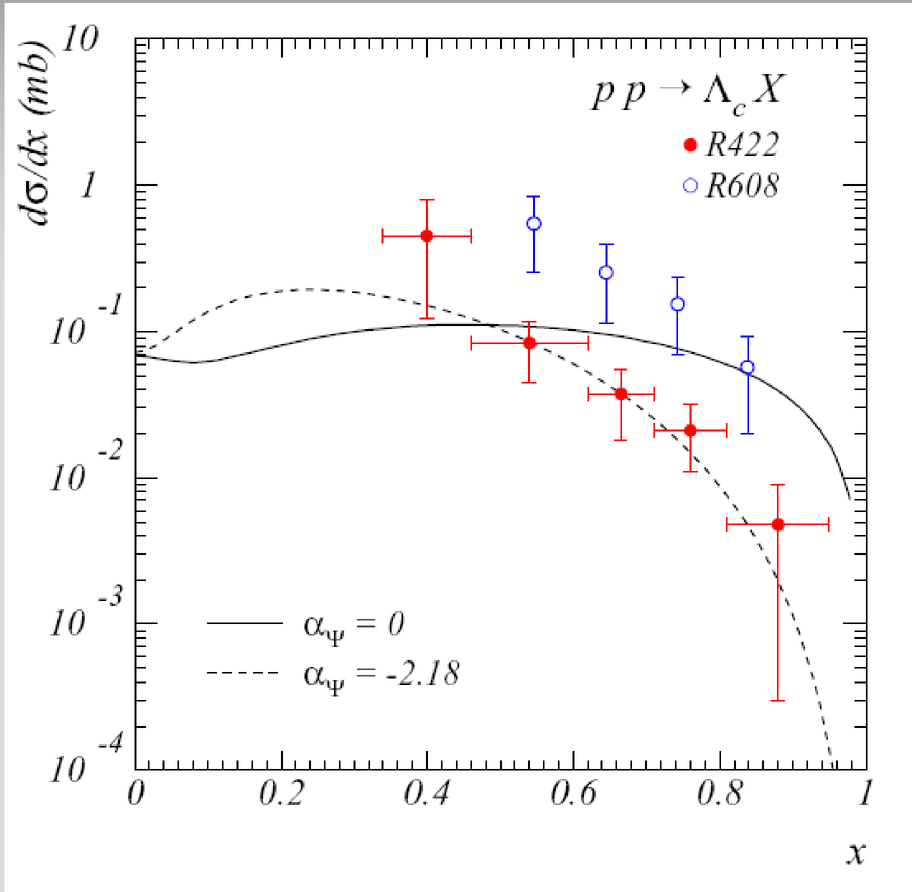


Figure 2: The differential cross section ***dσ/dx*** **for the inclusive process** ***pp***$\to\Lambda_c$**X at** $\sqrt{c} = 62\,GeV$ **. Experimental data: red points (R422) - G.Bari,et al, Nuovo Cim. A104, 571(1991); open blue circles (R608) - P.Chauvat,et al, Phys. Lett. B199, 304(1987)**

Beauty baryon production in p-p within the QGSM

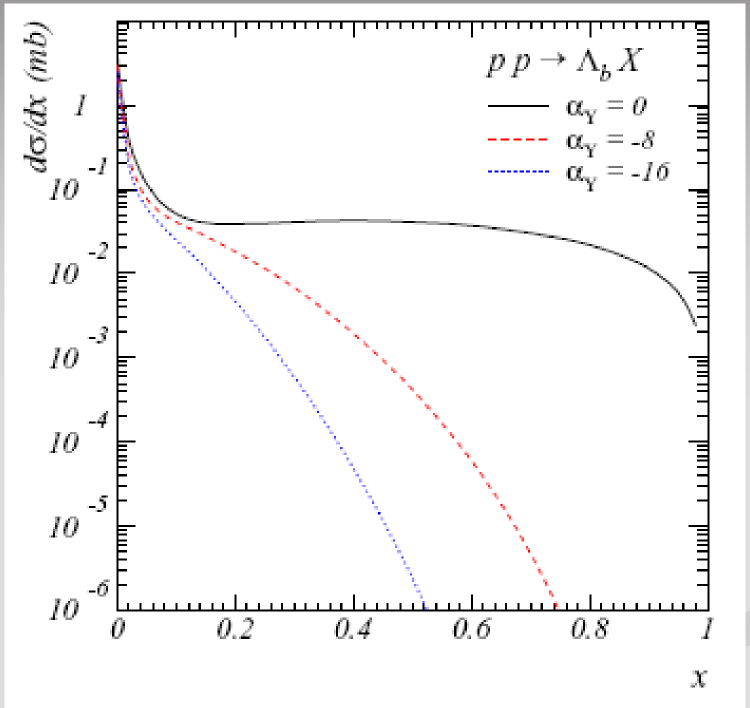


Figure 3: The differential cross section $d\sigma/dx$ for the inclusive process $p\to\Lambda_b X$ at $\sqrt{s} = 4 Tev$.

There are the experimental data on the Λ_b production in $p\bar{p}$ collisionand its decay $\Lambda_b \to J/\psi\Lambda^0$ obtained at the Tevatron. F.Abe, et al, Phys.Rev. D55, 1142 (1997).

$$f_{b(\bar{b})}(x) \sim (1 - x)^2, \textit{when} \quad \alpha_\gamma(0) = 0,\ f_{b(\bar{b})}(x) \sim x^{-8}(1 - x)^{10}, \textit{when} \quad \alpha_\gamma(0) = -8,$$

$$f_{b(\bar{b})}(x) \sim x^{-16}(1 - x)^{18}, \textit{when} \quad \alpha_\gamma(0) = -16.$$

Forward Λ_b production in p-p at LHC

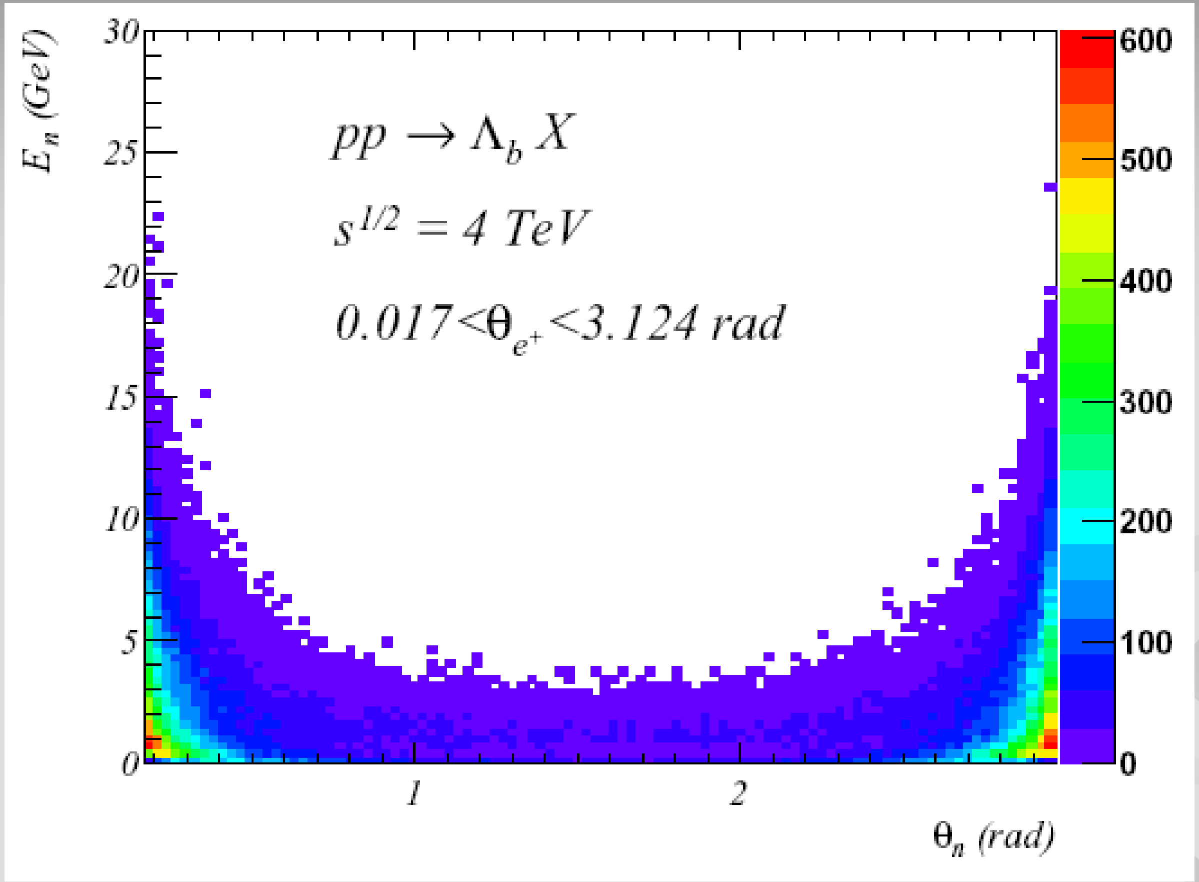


Figure 4: The distribution over θ_n and E_n in the inclusive process $pp \to \Lambda_b X \to J/\Psi \Lambda^0 X \to e^+ e^- n \pi^0 X$ at $\sqrt{s}$ = 4 TeV for all the electron energies; 1 gr. < θ_e < 179 gr. The fraction of these events is about 5.7 percent.

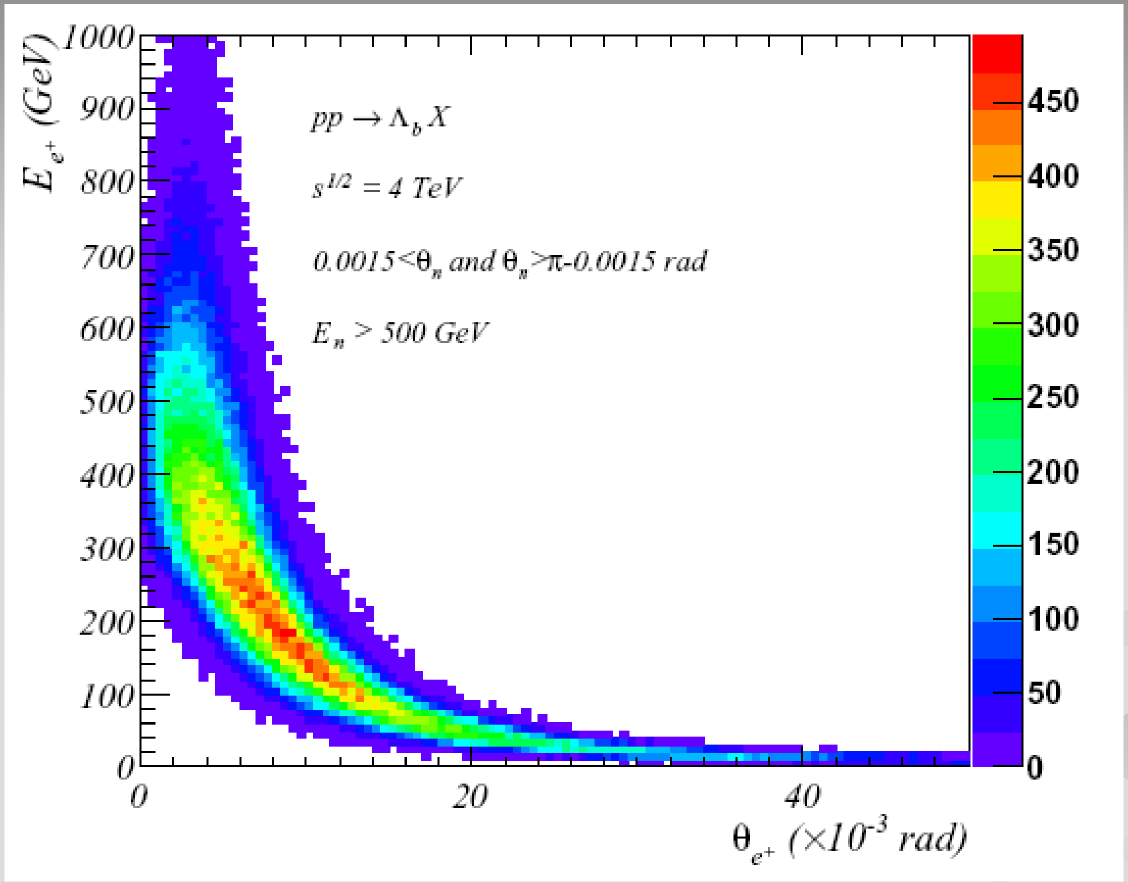


Figure 5: The distribution over θ_{e+} and E_{e+} in the inclusive process $pp\to\Lambda_b X\to J/\Psi\Lambda^0 X\to e^+e^- n\pi^0 X$ at $\sqrt{s}$ = 4 TeV; θ_n < 1.5mrad(0,5gr) for all the electrons. The fraction of these events is about 4.6 percent.

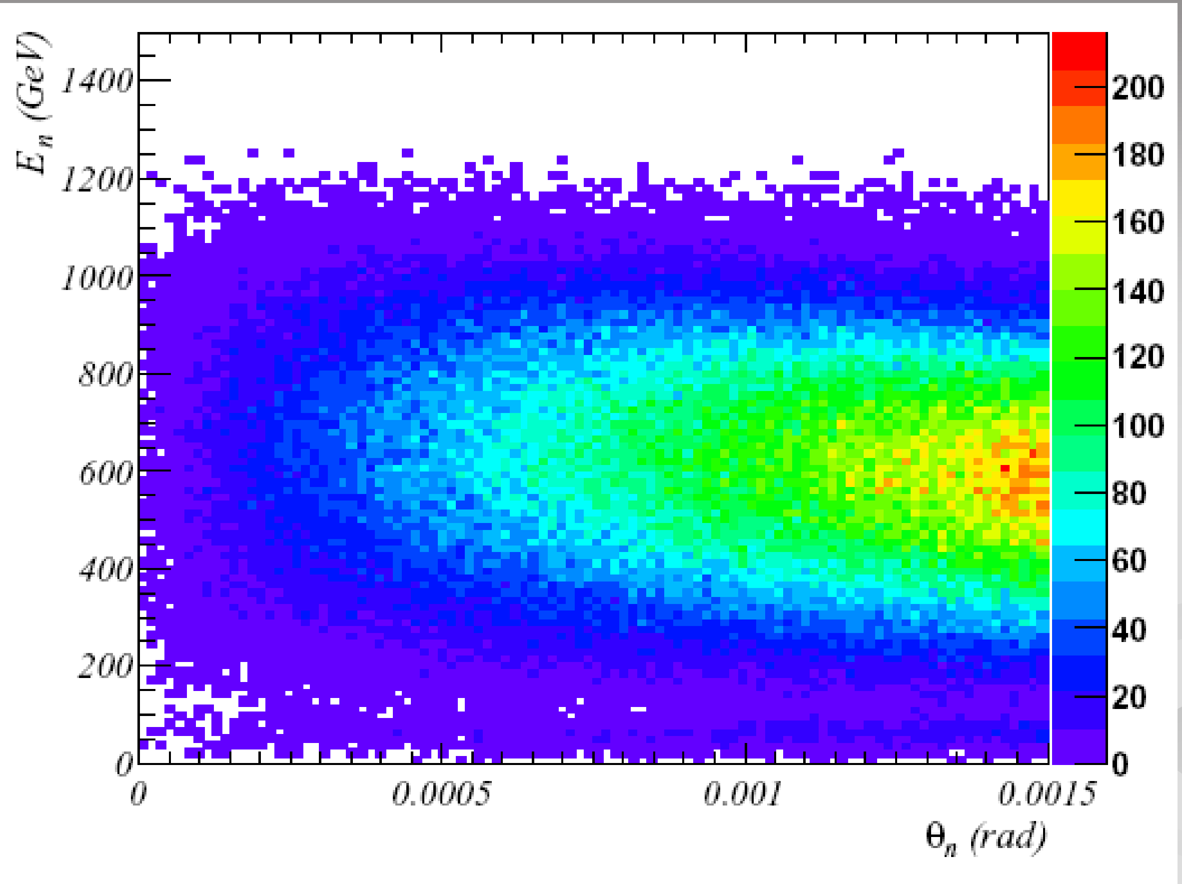


Figure 6: The distribution over θ_n and E_n in the inclusive process $pp \to \Lambda_b X \to J/\Psi \Lambda^0 X \to e^+ e^- n \pi^0 X$ at $\sqrt{s}$ = 4 TeV for all the electrons. The fraction of these events is about 3 percent.

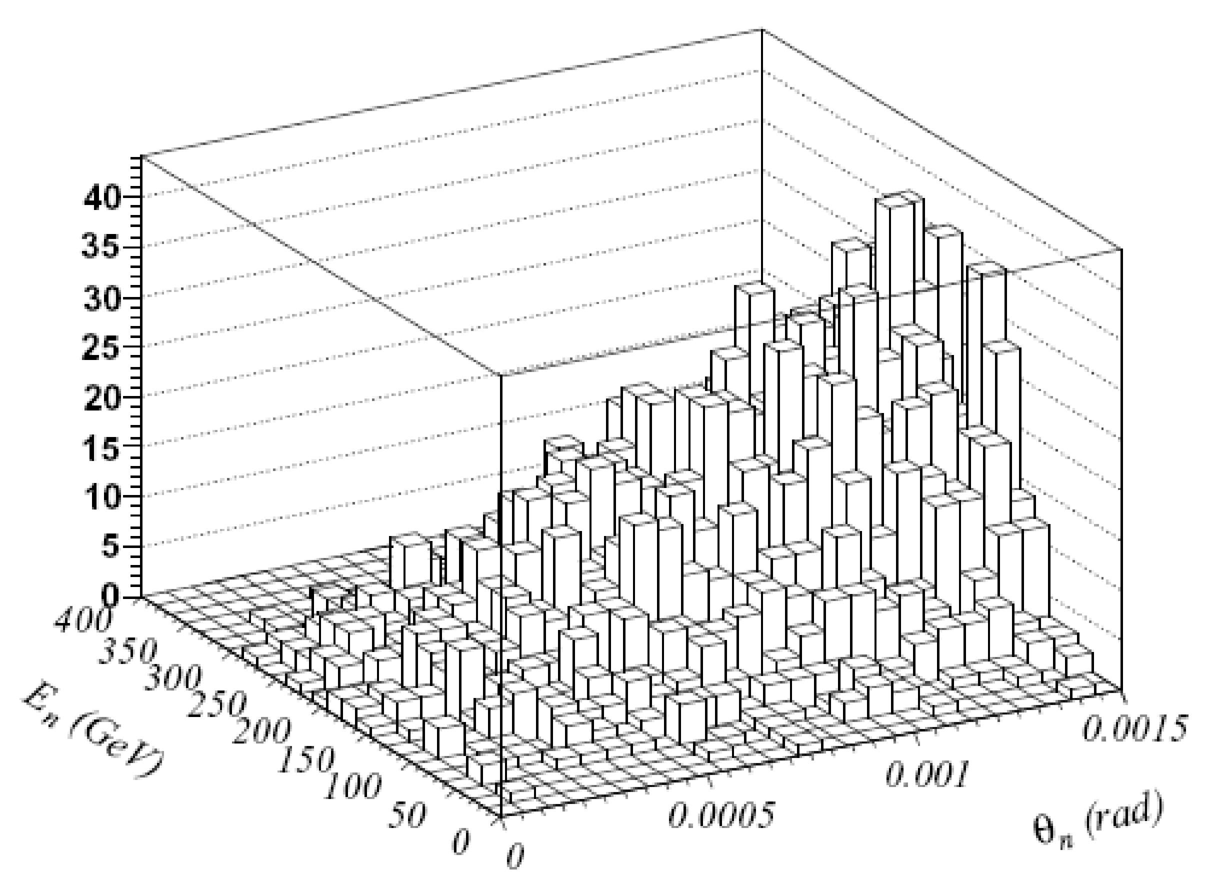


Figure 7: The distribution over θ_n and E_n in the inclusive process $pp \to \Lambda_b X \to J/\Psi \Lambda^0 X \to e^+ e^- n \pi^0 X$ at $\sqrt{s}$ = 4 TeV ; 1gr. < θ_e < 179gr. (TOTEM + CMS). The fraction of these events is about 0.1 percent.

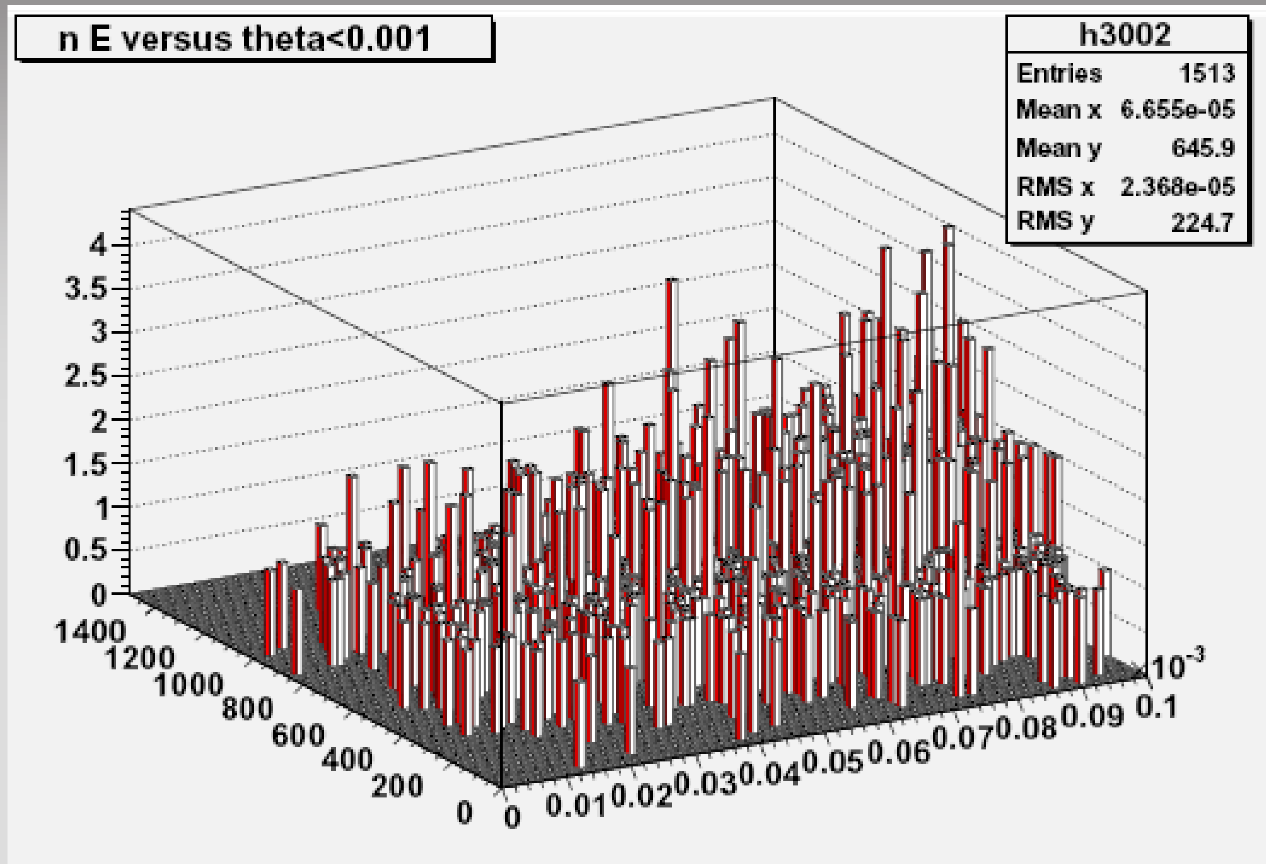
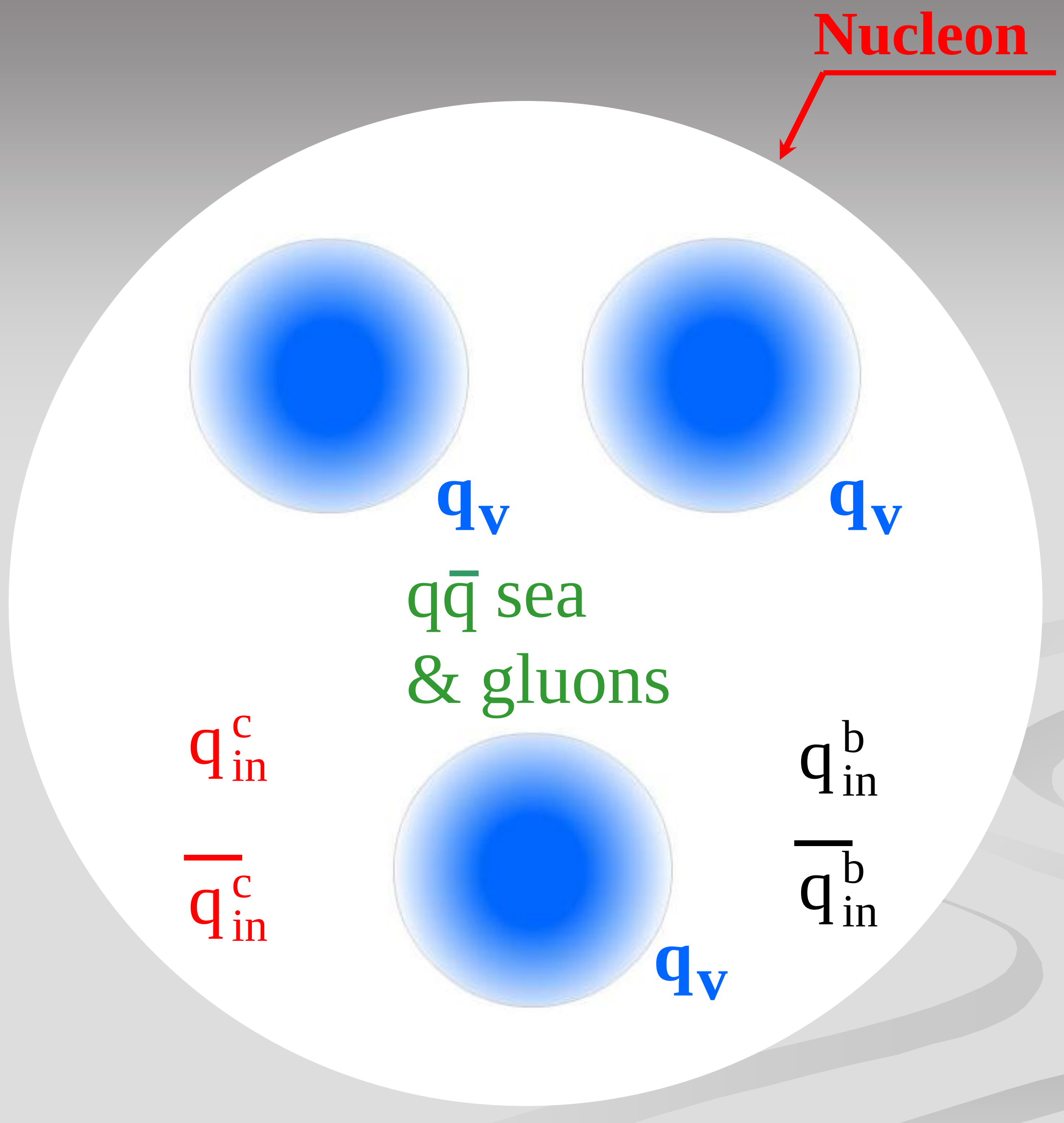


Figure 8: The distribution over θ_n and E_n in the inclusive process $pp \to \Lambda_b X \to J/\Psi \Lambda^0 X \to e^+ e^- n \pi^0 X$ at $\sqrt{s}$ = 4 TeV at θ_e < 0,1mrad and 1gr. < θ_e < 179gr. The fraction of these events is about 0.015 percent.


Nucleon
q_v
q_v
$q\bar{q}$ sea
& gluons
q^c_{in}
$\bar{q}^c_{in}$
q_v
q^b_{in}
$\bar{q}^b_{in}$

Intrinsic charm and beauty in proton

Intrinsic charm in proton

BHPS model

The 5-quark state $uudc\bar{c}$ in the proton is assumed

(S.L.Brodsky, P.Hoyer and N.Sakai, Phys.Lett. B 93, 451 (1980).)

Quasi-two-body state

The proton in the light-cone Fock space is as a superposition of configurations of off-shell physical

particles like $\bar{D}^0(u\bar{c})\Lambda_c^+(udc)$

(Jon Pumplin, Phys. Rev. D73,114015 (2006) and references there in)

The probability to find the intrinsic charm in proton is about 0.5 percent.

The form of the distribution of these quarks is similar to the form of the valence quarks.

Intrinsic beauty in proton

The probability to find the intrinsic beauty in proton is suppressed in comparison to the intrinsic charm probability by a factor $m^2_c\, m^2_b \sim 0.1$.

(M.V.Polyakov, A.Shafer and O.V.Teryaev, Phys.Rev D6-0, 051502 (1999); arXiv:hep-ph/9812393.)

SUMMARY

I. It is possible to observe the forward Λ_b production in p-p collisions decaying as $\Lambda_b \rightarrow J/\Psi \Lambda^0 \rightarrow e^+ e^- n \pi^0$ at the ATLAS using the ZDC. The fraction of these events is about 0.015 percent (45 pb) at $\sqrt{s}$ =4TeV.

II. Combining the TOTEM and CMS one can increase this fraction to 0.1 percent (300 pb).

III. The main goal of such predictions and the LHC experiments is to get the information on the Regge trajectories of the hidden bottom ($p\bar{p}$) mesons, the fragmentation functions of the quarks/diquarks to Λ_b, and the sea beauty quark distributions in the proton.

IV. The inclusion of the intrinsic beauty in the proton can increase the fraction of the Λ_b baryons produced forward in p-p collisions at the LHC energies.

Acknowledgments

THANK YOU VERY MUCH FOR YOUR ATTENTION !

We would like to thank also to
B.Batyunya, M.Deile, D.Denegri, P. Grafström, K.Eggert, Z.V. Krumstein, T.Lomtadze, A.Martin, V.Pozdnyakov and N.Zimin
for very useful discussions.