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Abstract

Here we compare the new data on b-quark production with prediction of the naive parton model and semihard approach, based on perturbative QCD.We claim that semihard approach gives the good description of CDF data on beauty production ,so we have now in hands the parametrization of gluon structure function that allows us to predict heavy quark production at higher (LHC and SSC) energies.

It is wellknown ,that heavy quark production cross section at high energy hadron collision is determined mostly by hard gluon-gluon interaction.The diagrams for amplitude of gluon-gluon fusion are shown in fig.1 in Born Approximation.In old parton model we used to calculate the cross section for heavy quark production by factorisation formula

$$\sigma(p\bar{p}) = \int dx_1 dx_2 x_1 G(x_1, q^2) x_2 G(x_2, q^2) \hat{\sigma}(gg \to Q\bar{Q}) \qquad (1)$$

where $x_i G(x_i, q^2)$ is the gluon structure function which scale q^2 is taken of the order of $q^2 \sim m_Q^2$ and $\hat{\sigma}(gg \to Q\bar{Q})$ is the cross section of hard subprocess $gg \to Q\bar{Q}$ at c.m. energy $\hat{s}_{gg} = x_1 x_2 s$. This cross section was calculated in refs.[1,2] within accuracy $O(\alpha_s^3)$ in perturbative QCD.

However,the recent experimental data from CDF collaboration at $\sqrt{s}$= 1.8 Gev [3] shows the value of cross section for beauty production in 3 times larger than the naive parton model prediction.In this paper we would like to draw attention to the fact that semihard phenomenology describes the experimental data and even more such large value of cross section for beauty production was predicted in framework of this approach (see ref. [4]).

The correct approach at low x to the calculation of the heavy quark production cross section was developed in refs [4-6] . The basical difference between naive parton approach and perturbative QCD calculations in the region of small x is the fact that we consider in QCD all the contributions of $(\alpha_s ln\frac{1}{x} F(q^2))^n$ type instead of $(\alpha_s ln\frac{m_Q^2}{\mu^2} F(x))^n$-type as was considered in the parton model.In particular, it means that in QCD we calculate the cross section of hard subprocess $\hat{\sigma}(gg \to Q\bar{Q})$ taking into account the corrections of the order of $\frac{q_{it}^2}{m_Q^2}$ where q_{it} is the transverse momentum of gluon (see fig.1).Such corrections were considered as small in leading $log\frac{m_Q^2}{\mu^2}$ approximation. However,in our case it changes the value of $\hat{\sigma}(Q\bar{Q})$ on approximatelly 20 per cent .But the main increase comes from the behaviour of gluon structure function $G(x,q^2)$ at low x.The point is that the summation of $(\alpha_s ln\frac{1}{x})^n$ terms leads to power-like increase of the gluon density $xG(x,q^2) \propto x^{-\omega_0}$,or ,numerically, $\omega_0 \sim \frac{1}{2}$ and so $xG(x,q^2) \sim \frac{1}{\sqrt{x}}$ where $x \sim \frac{2m_Q}{\sqrt{s}}$ [7,8].This increase continues up to saturation value $xG(x,q^2) \propto q^2 R^2$ [9] where the absorption corrections ceazes the further increase of $xG(x,q^2)$.Thus starting with the same function $G(x,q^2)$ at large $x \sim 0.3 - 0.1$ one gets the higher gluon density at small x ,say $x \leq 0.01$ then in the standart EHLQ or DO parametrization [10].

Finally the value of b-quark production cross section calculated in semihard approach (see ref.[4]) turns to be more than 3 times large at $\sqrt{s}$ =1.8 TeV then the parton prediction,fitting quite well the current CDF data .In figs.2 and 3 we compare the results of our calculation [4] (solid curves)with new experimental data reported at XXVI-th Recontres de Morion Conference and with parton model predictions (dashed curves).The $Sp\bar{p}S$ experimental data at $\sqrt{s}$=630 GeV are in reasonable agreement with the parton model calculation as well as ours ones. The Tevatron -collider data at $\sqrt{s}$=1.8TeV exeed significantly the parton model prediction and agree quite well with our calculations. In principle it could be connected with specific behaviour of the gluon distribution at low x .In such a case we expect considerable increase of b-quark or c-quark production cross section ratio at the same energy region.

It should be noted,that we do not use the new fitting parameters to get the curve given in figs.2,3. At first sight it seems strange,since we cannot guarantee the scale of logs in LLA.So we have at least two phenomenological parameters and to fix these scales: x_0 in $(ln\frac{x}{x_0}$ and q_0 in $ln\frac{q^2}{q_0^2}$). However,we have fixed all our parameters in previuos semihard phenomenology [11]. The gluon structure function $xG(x,q^2)$ we have finally used to (see eq.(5) in ref.[4]) does not contradict with the deep inelastic data and allows us to describe the minijet and inclusive hadron production at $Sp\bar{p}S$ - $FNAL$ tevatron collider energy region,as well as J/Ψ production at lower energies(see fig.4).

We would like also to note that in ref.[4] we probe several parametrizations of gluon structure function for better understanding of influence of the initial conditions on the final result.However the only one of them matches satisfactory with current experimental data for gluon structure function at x = 0.1-0.2.($xG(x,Q^2) \approx 1.2$ at $x = 0.15, Q^2 = 5GeV^2$).This parametrization (see eq.(5) in ref.[4] for details) at first sight looks strange and was chosen in a such way to simplify the calculation procedure.It should be stressed that namely this parametrization coincides numerically with the wellknown leading log(x) behaviour $xG(x,q^2) \propto x^{-\omega_0} \sim \frac{1}{\sqrt{x}}$ at $x \sim 0.01 - 0.15$[7,8]. The calculations with more consistent with LLA initial $xG(x,q^2)$ are in progress.

Thus,we hope that we have found the reasonable parametrization for gluon structure function which one can use to extrapolate the experimental heavy quark cross section to others kinematical regions.For example,using it we are able to estimate the total cross section for beauty production continuating the experimental data to small k_t region (see fig.3), as well as predict the rapidity distribution for beauty (see fig.5). Also we have prepared quite well to calculate the cross section of heavy quark production at higher energies for new generation of accelerators (LHC and SSC).The fact that CDF data follows our prediction encourages us to make such a calculation not only for beauty but also for heavier quarks as well as for charm. We would like also to note that the experimantal cross section for b- production depends mostly on the normalisation of the gluon structure function but the total cross section and charm production at Tevatron energies crucially depend on more dilicate properties of our approach such as shadowing and saturation of gluon density.

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Figure Caption

Fig.1: The diagrams for gluon -gluon fusion in heavy quarks.

Fig.2: Cross section of b -quark production at $\sqrt{s}$=0.63 TeV with $|y|$< 1.5 and $p_T > k_{min}$.Results of our and parton model (in $\alpha_s^2 + \alpha_s^3$ order of perturbative QCD [1]) calculations are shown by solid and dashed lines,respectively. Experimental data are taken from ref.[12].

Fig.3: Cross section of b-quark production at $\sqrt{s}$= 1.8 TeV with $|y|$< 1 and $p_T > k_{min}$.Results of our and parton model calculation (in $\alpha_s^2 + \alpha_s^3$ order of perturbative QCD [1]) are shown by solid and dashed lines ,respectively.Experimental data are taken from ref.[3].

Fig.4: The ratio of J/Ψ production cross section in pp and $p\bar{p}$ collisions.The curve corresponds to the quark structure functions of DO [10] and our parametrization of gluon distributions (eqs (5)-(7) in ref.[4].Experimental data are taken from ref.[13].

Fig.5: The rapidity distribution for beauty production at $\sqrt{s}$= 1.8TeV.

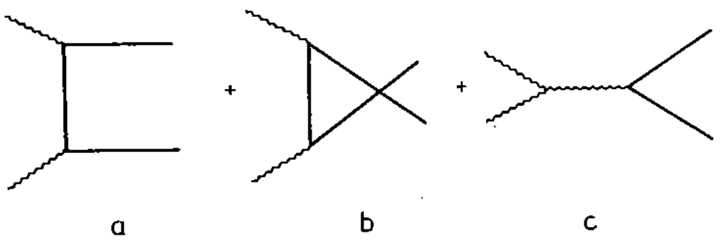

Fig.1

$\bar{p}p \to \bar{b}b$

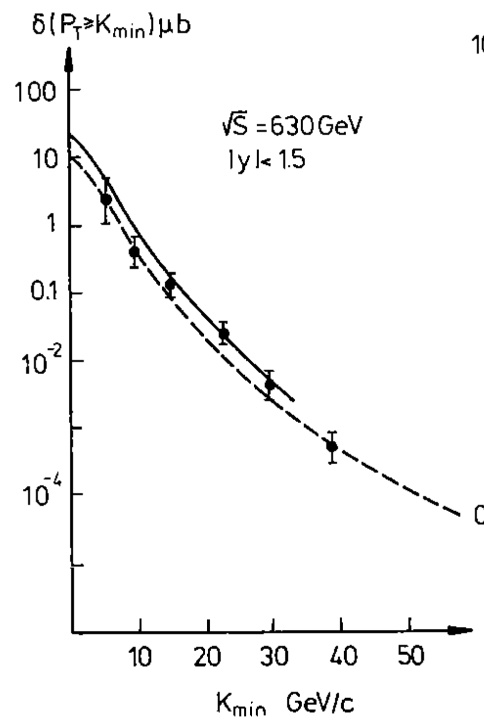

Fig.2

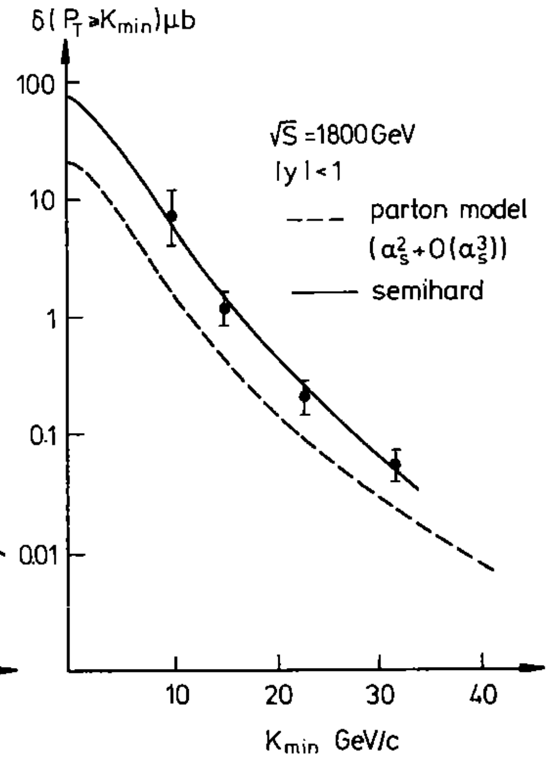

Fig.3

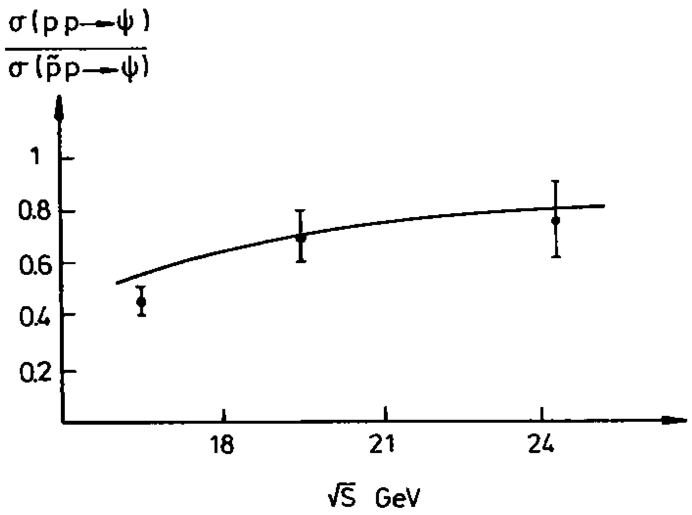
σ(pp→ψ) / σ(p̃p→ψ)
1
0.8
0.6
0.4
0.2
18
21
24
√S GeV

Fig. 4

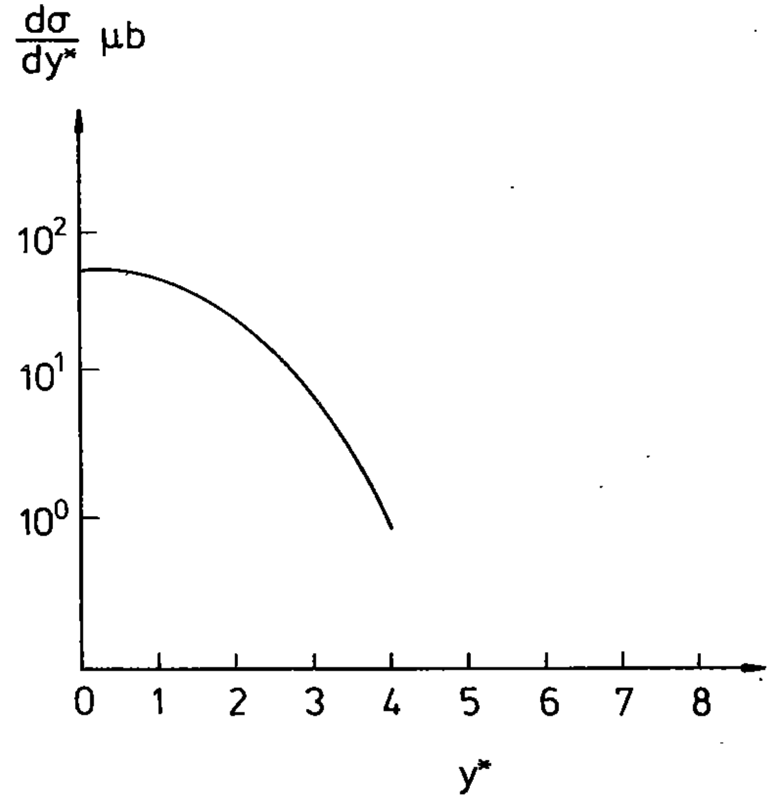
dσ/dy* μb
10^2
10^1
10^0
0
1
2
3
4
5
6
7
8
y*

Fig.5