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b-jet production via Reggeized gluon fusion at Tevatron and LHC

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We study inclusive b-jet and $b\bar{b}$-dijet production at the LHC and Tevatron invoking the hypothesis of gluon Reggeization in t-channel exchanges at high energy. The b-jet cross section includes contributions from open b-quark production in quasi-multi-Regge kinematics and from b-quark production via gluon-to-bottom-pair fragmentation within multi-Regge kinematics. We find good agreement with data by the ATLAS and CMS Collaborations at the LHC at the hadronic c.m. energy of $\sqrt{S} = 7$ TeV, and the data of CDF Collaboration at Tevatron at $\sqrt{S} = 1.96$ TeV.

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The high-energy regime of Tevatron and LHC, the so called "Regge limit" $\Lambda_{\rm QCD} \ll \mu \ll \sqrt{S}$, where μ is a characteristic scale of the relevant hard processes, the contribution of partonic subprocesses involving t-channel parton (gluon or quark) exchanges to the production cross section can become dominant. These $t-$channel exchanges obey (quasi-)multi-Regge kinematics ((Q)MRK), when the (groups of) particles produced in the collision are strongly separated in rapidity. For b-jet and $b\bar{b}$-dijet inclusive production it means that b-jet (MRK) or $b\bar{b}$-dijet (QMRK) is produced in the central region of rapidity, while other particles are produced with large modula of rapidities. The parton Reggeization approach (PRA) [1] is based on the hypothesis of parton Reggeization in $t-$channel exchanges at high energy [2]. Its theoretical background is to be the effective quantum field theory implemented with the non-Abelian gauge-invariant action including fields of Reggeized gluons and Reggeized quarks [2], proposed by L. N. Lipatov in 1995 [3].

We study a b-jet production in a region of b-quark transverse momenta $p_T \gg m_b$, where the large logarithms of type $\log(p_T/m_b)$ arise to all orders of $\alpha_s(\mu)$. They can be resummed in the fragmentation approach, where the main contribution comes from the gluon-to-bottom-pair fragmentation $g \to b\bar{b}$ which is described by a b-quark multiplicity in a gluon-initiated jet $n_g(\mu)$.

In the LO of PRA the dominative parton subprocesses for inclusive b-jet and $b\bar{b}$-jet production read: $R(q_1) + R(q_2) \to g(p)$ (MRK), $R(q_1) + R(q_2) \to b(p_1) + \bar{b}(p_2)$ (QMRK), which squared amplitudes are presented in the work [4] and R is the Reggeized gluon,

Exploiting the hypothesis of high-energy factorization, the master formula for the inclusive $b-$jet production takes a form, which is also kept for $b\bar{b}-$dijet production [4]:

$$\frac{d\sigma^{frag}(pp \to bX)}{dp_T dy} = \frac{1}{p_T^3} \int d\phi_1 \int dt_1 \Phi_g^p(x_1, t_1, \mu^2) \Phi_g^p(x_2, t_2, \mu^2) n_g(\mu) \overline{|\mathscr{M}(RR \to g)|^2}, \quad (1)$$

where y is the rapidity of $b-$quark, ϕ_1 is the azimuthal angle between $\vec{q}_{1T}$ and $\vec{p}_T$, $x_{1,2} = \dfrac{p_T \exp(\pm y)}{\sqrt{S}}$, $t_2 = t_1 + p_T^2 - 2\sqrt{t_1} p_T \cos(\phi_1)$. The unintegrated PDFs Φ_g^h of Reggeized gluons in hadrons h are obtained from the integrated one, by the prescription proposed by Kimber, Martin, and Ryskin (KMR) [5], as default, and by the Blümlein approach [6], to estimate the theoretical uncertainty.

We describe the ATLAS data on $b\bar{b}$-jet-production at LHC at $\sqrt{S} = 7$ TeV [7] well with our LO parton Reggeization approach predictions at the whole presented range of the $b\bar{b}$-dijet invariant mass M_{jj} (Fig. 1, left), the azimuthal angle between the two jets $\Delta\phi$ and the angular variable χ.

For the inclusive b-jet transverse-momentum production spectra we account gluon-to-bottom-pair production mechanism and consider the function of $b\bar{b}$-pair multiplicity $n_g(\mu)$ in a gluon jet as a free phenomenological parameter, which we extract from the ATLAS data for the inclusive b-jet production spectra [7]. We propose the analytical approximation of $n_g(\mu) = A \ln \frac{\mu^2}{m_b^2}$ with $m_b = 4.75$ GeV and $\mu = p_T/4$, and found $A_{KMR} = 0.0012$ and $A_B = 0.0027$, that at the scale $\mu \simeq m_Z/4$ is in agreement with the measurements at the LEP Collider [8]. Using the extracted $n_g(\mu)$ we demonstrate good agreement with ATLAS (Fig. 1, right) and CMS data at the CERN LHC, and CDF data at the Fermilab Tevatron [9]. In all cases we find a good agreement between theoretical predictions and experimental data.

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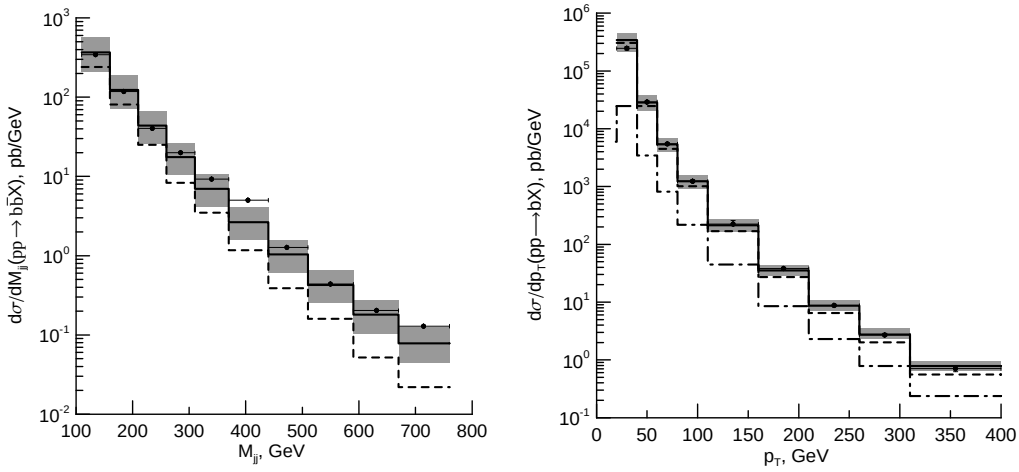

Figure 1: At left: the $b\bar{b}$-dijet cross-section for b-jets with $p_T > 40$ GeV, $|y| < 2.1$, as a function of dijet invariant mass M_{jj}. The solid polyline with shaded bands correspond to KMR PDF with theoretical uncertainties, the dashed one – to Blümlein PDF. At right: inclusive differential b-jet cross-section as a function of p_T, the dashed polyline corresponds to the open b-quark production, the dashed-dotted one — the gluon-to-bottom-pair fragmentation, the solid — sum of all them, $|y| < 2.1$. Points – ATLAS data [7].

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