Charged hadron production in proton-proton collisions at LHC energy

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Inclusive charged hadron production in proton+proton collision can be used as a very efficient and precise tool to probe various aspects of Quantum Chromodynamics (QCD). The perturbative QCD (pQCD) well describes the high p_T regime of the spectrum originating from the hard partonic collisions. With the increase in colliding energy one can probe the low Bjorken-x physics, which is dominated by the gluons. In the present work we make an attempt to study the particle production at LHC energies using the next to leading order(NLO)formalism outlined by Owens et al. [1] in perturbative QCD processes involving gluonic interactions.

The invariant cross section, $Ed^3\sigma/d^3p$ for particle production in the proton-proton collision, can be obtained by using the formalism outlined in Ref [2]. For the partonic interaction, we consider the process $g(k_1) + g(k_2) \rightarrow g(k_3) + g(k_4) + g(k_5)$ having the invariant amplitude as [1]:

$$|M_{gg\rightarrow ggg}|^2 = \left(\frac{4g^4 N_c^2}{N_c^2 - 1}\frac{s^2}{(q_\perp^2 + \Lambda^2)^2}\right) \left(\frac{4g^2 N_c q_\perp^2}{k_\perp^2[(k_\perp - q_\perp)^2 + \Lambda^2]}\right) + \frac{16g^6 N_c^3}{N_c^2 - 1}\frac{q_\perp^2}{k_\perp^2[(k_\perp - q_\perp)^2 + \Lambda^2]} \quad (1)$$

where $k_\perp$ is the transverse component of k_5 and $q_\perp$ is the perpendicular component of the momentum exchanged in the centre of momentum frame, Λ is the QCD scale and N_c is the number of colour degrees of freedom. We have taken $\Lambda = 200$ MeV. The invariant amplitude contains the corrections to the well known formula derived by Gunion-Bertsch in [3]. The estimated magnitude of the correction (to GB formula) is about $20 - 30\%$ in the present case.

The contribution from the process $g + g \rightarrow g + g$ to the invariant amplitude:

$$|M_{gg\rightarrow gg}|^2 = \left(\frac{4g^4 N_c^2}{N_c^2 - 1}\frac{s^2}{(q_\perp^2 + \Lambda^2)^2}\right) \quad (2)$$

is also taken into account in this work.

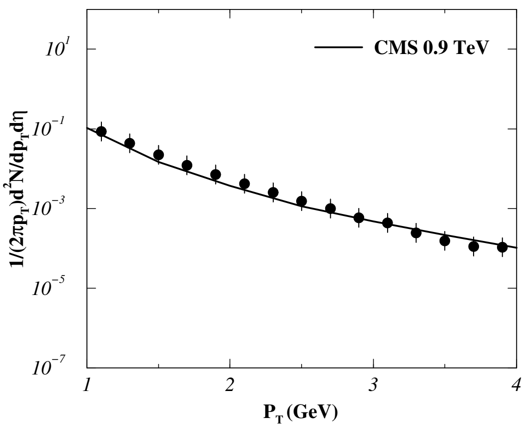

FIG. 1: Transverse momentum distributions of charged hardons produced in the proton-proton collisions at 0.9 TeV. The experimental data (solid circles) has been taken from Ref [5]

The single inclusive hadron distribution is obtained by convolving the gluon production with the fragmentation function for gluons into charged hadrons. The expression for the invariant cross sections is given by

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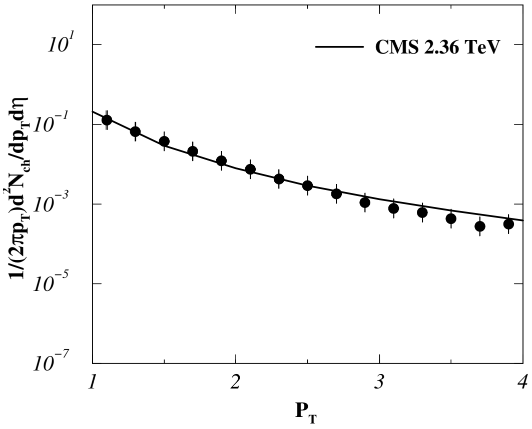

FIG. 2: Transverse momentum distributions of charged hardons produced in the proton-proton collisions at 2.36 TeV. The experimental data (solid circles) has been taken from Ref [5].

$$E\frac{d^3\sigma}{d^3p}(AB \to h + X) = \int dx_a dx_b dz_c G_{A/a}(x_a) G_{B/b}(x_b) D_{h/c}(z_c) \frac{\hat{s}}{\pi z_c^2} \frac{d\sigma}{d\hat{t}}(ab \to cd) \delta(\hat{s} + \hat{u} + \hat{t}) \quad (3)$$

where $G_{A/a}$ and $G_{B/b}$ are the relevant parton distribution and $D_{h/c}$ is the fragmentation function. The fragmentation function is taken from Ref [4].

In Fig. 2 we display the transverse momentum distributions of the charged hardons produced in the proton-proton collisions at 2.36 TeV measured by the CMS collaboration. The experimental data is compared with the theoretical results (solid line). There is no overall K factor used here. The agreement is reasonably well. The reproduction is well with the gluonic contributions only because the collisions at LHC energy is dominated by gluons. The quark contribution to the transverse momentum distributions of the produced particle may be important at lower beam energies.

In Fig. 1 we display the transverse momentum distributions of the charged hardons produced in proton-proton collisions at 0.9 TeV measured by the CMS collaboration. The agreement between the data and the theoretical calculation is reasonable well. Again pointing out to the fact that gluons play dominant role at high energy hadronic interactions.

In summary we have calculated the transverse momentum distributions of the charged hardons produced in the proton-proton collisions at 2.36 and 0.9 TeV using the NLO perturbative gluonic processes. Our model calculation well reproduced the experimental data measured by the CMS collaboration. The results for other beam energies including the contributions from quarks will be presented in the symposium.

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