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# Role of quarks in hadroproduction in high energy collisions

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**Abstract**

A qualitative model for hadroproduction in high energy collisions considering two components ("thermal" and "hard") to hadroproduction is proposed. Inclusive pseudorapidity distributions, $d\sigma/d\eta$, and transverse momentum spectra, $d^2\sigma/(d\eta dp_T^2)$, measured by different collaborations are considered in terms of this model. The shapes of the pseudorapidity distributions agree with that one can expect from the qualitative picture introduced. The model is used to provide predictions for the LHC. Data up to a centre-of-mass energy of 7 TeV are well described and predictions for higher energies await new data. Finally, the differences between charged particle spectra produced in inclusive and diffractive events are discussed and the absence of the "thermal" component in the latter is observed.


## 1. Introduction

One can decompose hadroproduction in baryon–baryon high energy interactions into at least two distinct sources. The first one is associated with the baryon valence quarks and a quark–gluon cloud coupled to the valence quarks. Those partons exist before the interaction and could be considered as being a thermalized statistical ensemble. When a coherence of these partonic

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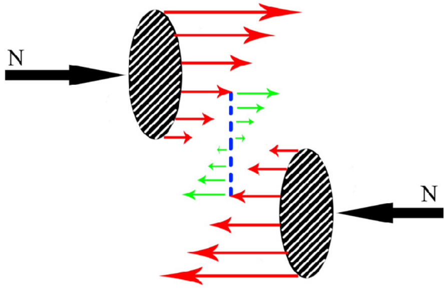


Fig. 1. Two different sources of hadroproduction: red arrows – particles produced by the existing partons, green – particles produced via the mini-jet fragmentation. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

systems is destroyed via the strong interaction between the two colliding baryons, these partons hadronize into particles released from the collision. The hadrons from this source are distributed in the transverse plane with respect to the interaction axis according to the Boltzmann-like exponential statistical distribution [1]. The second source of hadrons is directly related to the mini-jet fragmentation of the virtual partons (pomeron in pQCD) exchanged between two colliding partonic systems. The radiated partons from this pomeron have a pQCD power-law spectrum [2]. Schematically Fig. 1 shows these two sources of particles produced in high energy baryonic collisions.

Thus, one can study charged particle production using the *two component* parametrization [3], combining exponential (Boltzmann-like) and power-law $p_T$ distributions:

$$\frac{d\sigma}{p_T dp_T} = A_e \exp\left(-E_{T\,kin}/T_e\right) + \frac{A}{(1+\frac{p_T^2}{T^2 \cdot n})^n}, \tag{1}$$

where $E_{T\,kin} = \sqrt{p_T^2 + M^2} - M$ with $M$ equal to the mass of the produced hadron. $A_e$, $A$, $T_e$, $T$, $n$ are the free parameters to be determined by fit to the data. The detailed arguments for this particular choice are given in [3]. A typical charged particle spectrum as a function of transverse energy, fitted with this function (1) is shown in Fig. 2. As one can see, the exponential term dominates the particle spectrum at low $p_T$ values.

The introduced parametrization (1) provides a perfect description of the experimental data over the full kinematic region except the lowest-$p_T$ point ($\approx$75 MeV) (Fig. 2). Unfortunately, all other experimental data measured in various collider experiments do not cover this kinematic region ($p_T < 100$ MeV). Therefore, further precise measurements of the low transverse momentum particles will help in understanding the observed discrepancy.

## 2. Pseudorapidity distributions

Let us first discuss the charged particle production in $pp$ collisions as a function of pseudorapidity in terms of the qualitative picture for hadroproduction introduced above. From the naive point of view, hadrons produced via the mini-jet fragmentation should be concentrated in the central rapidity region ($\eta \sim 0$), while those coming from the proton fragmentation are expected to dominate at high values of $\eta$ due to non-zero momenta of the initial partons along the beam-axis. To check this prediction we use data published by the UA1 experiment [4] which are presented as cross-sections $d^2\sigma/(d\eta dp_T^2)$ for $pp$ collisions in five pseudorapidity bins, covering the total rapidity interval $|\eta| < 3.0$.