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Soft and semi-hard components of multiplicity distributions in the k_T factorization approach

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The multiplicity distribution (MD) of charged particles in high-energy proton-proton collisions remains an intricate aspect of quantum chromodynamics (QCD). Traditional models, such as the Negative Binomial Distribution (NBD), were fitted and successfully described MDs at lower energies, but fail at higher energies, such as those probed by the Large Hadron Collider (LHC), where a "shoulder-like" structure emerges.

To address this, we employ the Double Negative Binomial Distribution (DNBD), a weighted combination of two NBDs, representing contributions from soft and semi-hard processes. This model typically involves six free parameters, but by incorporating the k_T factorization formalism and introducing an energy scale Λ, we effectively reduce the number of free parameters to four while maintaining a strong fit to high-energy MD data. The unintegrated gluon distribution used in this work is derived from the Golec-Biernat–Wüsthoff (GBW) model.

Additionally, we investigate the KNO scaling and use the k_T factorization formalism to describe the pseudo-rapidity distribution. Our approach demonstrates excellent agreement with recent experimental data, yielding low χ^2 values and highlighting the potential for improvements using more realistic gluon distribution model. This analysis provides valuable insights into the interplay of soft and semi-hard processes in high-energy collisions.

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