Description of $\langle p_T \rangle$ - $N_{ch}$ correlations in pp, pA and AA collisions in Monte Carlo model based on the interaction of color diopes

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Abstract and motivation

The correlation between the mean transverse momentum and the multiplicity of charged particles, recently measured by the ALICE experiment in pp, pA and AA Pb-Pb collisions at the LHC [1], is studied in the framework of string-parton Monte-Carlo model [2, 3], in which the elementary collisions are realized by interactions of color diopes. It enables to describe pA and AA scattering without referring to the Glauber picture of independent nucleon collisions and to include an account of string fusion (4 - 6) as a source of collective effects.

The model reproduces multiplicity yields in wide energy range (from ISR to LHC) as well as the transverse momentum dependence of the multiplicity in Pb-Pb collisions. The results obtained in the framework of the model for $\langle p_T \rangle$ - $N_{ch}$ correlations describe the main features of the experimental data. The contribution of different mechanisms to $\langle p_T \rangle$ - $N_{ch}$ correlation is analyzed.

Monte-Carlo model

- Partonic picture of nucleons interaction [2, 3].
- Energy and angular momentum conservation in the initial state of a nucleon.
- The probability of diopes interaction depends on their transverse coordinates [7-8] with effective coupling:

$$f = \frac{1}{2} \sum_{i} \sum_{j} \rho_i \rho_j$$

- Multiplicity and transverse momentum are obtained in the approach of colour strings, stretched between projectile and target partons.
- The interaction of strings is realized in the accordance with the string fusion model prescriptions [4-6]. Mean multiplicity and the mean transverse momentum of the particles produced from a cluster of strings are:

$$\langle N_p \rangle = p_T \sum_{i} \sum_{j} \rho_i \rho_j S_{ij}$$

- $\rho_i$, $\rho_j$ - mean multiplicity and transverse momentum from one string.

- Multiplicity from one string is distributed according to Poisson distribution, with Gaussian transverse momentum spectra.

- The hardness of the elementary collisions is either constant ($\rho_0$) - in case of no hard subprocess; or it is defined by a transverse size of the interacting diopes, $d_T$, similarly to DIPSY [8, 10].

- In case of hard process, the transverse momentum of a cluster of strings is:

$$p_T = \sum_{i} p_{T_{str}}^i$$

- Every parton can interact with other only once (contrary to Glauber supposition of constant nucleon cross section).

- Parameters of the model are constrained from the data on total inelastic cross-section and multiplicity [2, 11], with mean transverse momentum $\langle p_T \rangle = 0.2 - 0.3$ fm in case with string fusion, and $\langle p_T \rangle = 0.2 GeV/c$ in case with the hard process or $\rho_0 = 0.4 GeV/c$ without hard process.

Results: pt-n correlations in pp collisions

- Inclusion of hard process is necessary in order to reproduce the transverse momentum spectra of charged particles in pp collisions.

- Reasonable good description of transverse momentum spectra of charged particles in the MC model with string fusion and hard process included.

Results: pt-n correlations in p-Pb collisions

- String fusion or hard process separately are not sufficient to describe experimental correlation between transverse momentum and multiplicity.

- MC model with hard process only behaves like Pythia 8 [17] without color reconnection [18] - almost flat function with small slope

- Inclusion of both hard process and string fusion enables to describe data.

Summary and conclusions:

- The Monte Carlo model reasonably describes the charged particles transverse momentum spectra and nuclear modification factor at the LHC energies.

- The main features of the correlation between transverse momentum and multiplicity are reproduced in the model.

- The major mechanisms that contribute to the correlation function between transverse momentum and multiplicity are the following:

  - Hardness of the elementary collision, which is found to be multiplicity depended, is relevant for $\langle p_T \rangle$ - $N_{ch}$ correlation at smaller multiplicities and is responsible for the whole transverse momentum.

  - String fusion multiplicatively enhances the $\langle p_T \rangle$ - $N_{ch}$ correlation function.

  - In AA collisions, the parton energy loss possibly can give a considerable contribution to the mean transverse momentum.

References

11. V. V. Kovalenko, PoS (QFTHEP 2013) 052 (2013).