Angular correlations with charmed hadrons in the Monte-Carlo model with string repulsion

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Introduction

Color flux tubes (quark-gluon strings), formed at early stages of hadron-hadron collision, may overlap in case of sufficiently high densities and interact by repelling or attracting each other, depending on the direction of the color fluxes [1]. Thus, the hypothesis of repulsive interaction, strings may acquire, before the hadronization, an additional transverse boost. This produces additional transverse momenta to the particles formed in string decays over a wide range of rapidity, thus leading to modification of observables and to azimuthal asymmetry of two-particle correlations. Monte Carlo implementation of the model is described in [2]. Recent experimental results revealed large elliptic flow of the charged hadrons at LHC energies. These measurements are often interpreted using transport models, which incorporate dissociation and recombination mechanisms for charm quark. For this report, azimuthal correlations with charmed hadrons are calculated in MC model with string repulsion, assuming that D mesons can fly off the nucleons due to the strong radial flow at LHC energies.

Stage 1. Simulation of strings configuration
- Nuclei: Pb-Pb, the Woods-Saxon radius is 6.62 fm, a = 0.546 fm
- inside each nucleon partons are distributed in transverse (xy) plane with 2D-Gauss law, with \( a_y = 0.4 \) fm.
- The mean number of partons inside nucleons depends on a collision energy and is a model parameter.
- Partons can interact and form a string, if the distance between partons in xy plane is less then some parton interaction distance dp. There is a \( \approx 3\% \) probability to have “hard scattering” of partons (to emulate mini-jets and hard spectra).
- All strings are considered to be “soft” and “long” in rapidity, occupying rapidity range \( y \in [-4, 4] \).

Stage 2. Repulsion of the strings
- Strings have effective interaction radius \( R_{int} \).
- Strings overlaps which leads to repulsion, string boost is adjusted to \( \frac{1}{R_{int}} \) in central Pb-Pb collisions
- Each string breaks into quark-antiquark pairs in several places, forming a number of mesons (pions and \( p \rightarrow \pi \)).
- Transverse Lorentz boost \( p_{trans} \) is applied for each particle (green arrows on cartoon).

Stage 3. String hadronization
- The “harmonic decomposition” of the azimuthal profile of the correlation function for most central for charged particles with \( p_T > 0.15 \) Gev.
- Calculations with the MC model with string repulsion show qualitatively similar behaviour as in data. Quantitative discrepancies are due to [1] different treatment of \( \langle N_{part} \rangle \) in the MC model and [2] approximations in description of the “hard” contribution.

The MC model with string repulsion

Due to string-string interactions, initial configuration of quark-gluon strings could be transferred into the azimuthal flow [3]. Two-particle correlation functions obtained in the toy model for peripheral (left), semi-central (middle) and central (right) events are shown in the Figure below for charged particles with \( p_T > 0.15 \) Gev, with string effective interaction radius 2 fm. The pads in the Figure illustrate the onset of collectivity when passing from peripheral to central A-A collisions. In peripheral events, a structure along \( \Delta \phi \) is visible, which is due to the \( p_T \) decays into pions.

Two-particle \( \Delta \phi \)-\( \Delta p_T \) correlations

For \( \Delta \phi \), mass ordering is also clearly visible in data, also seen for D meson. Theoretical calculations for D meson \( V_2 \) usually use in-vacuum fragmentation of heavy quarks for the high-momentum region, supplemented by hadronization via recombination at low momentum, some models also include scattering of D mesons in the hadronic phase of the medium.

Conclusions

- It is shown that signatures of collectivity, observed experimentally in A-A collisions, can be obtained in the model with repulsing strings. Namely, the model qualitatively reproduces mass ordering of the nuclear modification factor and azimuthal flow for light flavours, as well as for heavier hadrons, for instance, D mesons (assuming possibility for a string to hadronize into charmed hadrons).
- The main challenge for the model to get better quantitative agreement with data is to reproduce correctly an interplay between soft and hard contributions in intermediate \( p_T \) range (from 1 to 8 GeV, depending on particle species).
- To reproduce \( V_2 \) formalism on \( N_{part} \) should be done in the same way as in data (Glauber approach without details at partonic level).

REFERENCES


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