Enhanced Yield of Strange and Heavy-Flavour Particles from Few-Nucleon Clusters In High Energy pA Collisions

Vladimir VECHERNIN
Saint-Petersburg State University

Abstract

The possible correlation between the yield of strange and heavy-flavour particles and the production of nucleon clusters is explored as an experimental phenomenon. The so-called cumulative region of pA collisions is studied. The particle production in the cumulative region is considered in a trigger, confirming participation in the process of a dense few-nucleus cluster. From the modern point of view this cold dense nuclear matter clusters (fluctuations), previously presented in nuclei, should be regarded as multi-quark bags similar to the droplets of cold quark-gluon plasma.

For the description of particle production from such objects, the scheme based on the evaluation of the QCD diagram near thresholds [3,4] is applied in this approach. The production of quark jets in this process is described by the fragmentation of a fast cumulative quark (2,3,4), whereas in the production of protons is dominated by the coherence of amplitudes of these fast quarks from the cluster (2,3,4). This approach, in particular, has already allowed to describe the transverse-momentum dependence of the yields both of the protons and the protons in the cumulative region, using the only parameter - the constituent quark mass, to be equal 350 MeV/c^2.

In present work, using the string fragmentation model, we analyse the fragmentation of the nuclear cluster residue after the emission of a particle in cumulative region. Previous studies [2,4] show that the diagrams are dominant, which are at low quark of the cluster (for instance, compensating the momentum of the fast quark(s)) must interact with the string. At the same time these string production processes leading to a shock confinement in transverse plane of the reaction. As a consequence the strings formed in the interactions of the string parton with the quark(s) occur strongly overlapped in the impact parameter. This leads to the appearance of the string production due to string fusion processes. As known, these processes lead to the additional production of heavy flavor such as B, K for the case of cumulative strange production. Along with the usual strangeness-limited version of a string fragmentation we consider also the modified version leading to the thermal-like spectra [2,4], what results in the increased production of strange and heavy flavour particles [3,4].

Using this picture we calculate the strength of the correlation of the yield of particles in the backward cumulative hemisphere and the magnitude of additional forward-prime and charm-particle production in relation to this admixture. The possibility of experimental observation of the given phenomena is also discussed.

References:


The observables

We define the two class of events with and without the particle (proton or pions) with a contamination of rapidity:

\[ \Delta y = y_N - y_{0} \]

In described approach we expect that \( \Delta y > 1 \)

The restriction to the rapidity region \( \Delta y > 1 \) is necessary to suppress the increase of the phase volume of the fast cumulative quark, which at low quark of the cluster (for instance, compensating the momentum of the fast quark(s)) must interact with the string. At the same time these string production processes leading to a shock confinement in transverse plane of the reaction. As a consequence the strings formed in the interactions of the string parton with the quark(s) occur strongly overlapped in the impact parameter. This leads to the appearance of the string production due to string fusion processes. As known, these processes lead to the additional production of heavy flavor such as B, K for the case of cumulative strange production. Along with the usual strangeness-limited version of a string fragmentation we consider also the modified version leading to the thermal-like spectra [2,4], what results in the increased production of strange and heavy flavour particles [3,4].

The non-perturbative contribution to the production of heavy flavour particles, due to the additional string fusion effects in fluctuation region, can be more noticeable at small initial energies in fix target pA experiments, as in discussed future experiments with modified NA61 at SPS. We also expect that this contribution will manifest itself more clearly in colliders with high jet (gluon, pion), because of the absence of other strange-fusion effects.

The work was supported by the RFBR grant 18-02-40075 and by the Saint Petersburg State University outgoing academic mobility grant id 40214007.

Summary:

1) So in this approach based on the combination of two complementary models (flucton cumulative fragmentation + string fusion) we can expect the positive correlation between production of particle in the backward cumulative region and relative yield of heavy flavors in forward direction.
2) The non-perturbative contribution to the production of heavy flavour particles, due to the additional string fusion effects in fluctuation region, can be more noticeable at small initial energies in fix target pA experiments, as in discussed future experiments with modified NA61 at SPS. We also expect that this contribution will manifest itself more clearly in colliders with high jet (gluon, pion), because of the absence of other strange-fusion effects.

The observables

We define the two class of events with and without the particle (proton or pions) with a contamination of rapidity:

\[ \Delta y = y_N - y_{0} \]

In described approach we expect that \( \Delta y > 1 \)

The restriction to the rapidity region \( \Delta y > 1 \) is necessary to suppress the increase of the phase volume of the fast cumulative quark, which at low quark of the cluster (for instance, compensating the momentum of the fast quark(s)) must interact with the string. At the same time these string production processes leading to a shock confinement in transverse plane of the reaction. As a consequence the strings formed in the interactions of the string parton with the quark(s) occur strongly overlapped in the impact parameter. This leads to the appearance of the string production due to string fusion processes. As known, these processes lead to the additional production of heavy flavor such as B, K for the case of cumulative strange production. Along with the usual strangeness-limited version of a string fragmentation we consider also the modified version leading to the thermal-like spectra [2,4], what results in the increased production of strange and heavy flavour particles [3,4].

The observables

We define the two class of events with and without the particle (proton or pions) with a contamination of rapidity:

\[ \Delta y = y_N - y_{0} \]

In described approach we expect that \( \Delta y > 1 \)

The restriction to the rapidity region \( \Delta y > 1 \) is necessary to suppress the increase of the phase volume of the fast cumulative quark, which at low quark of the cluster (for instance, compensating the momentum of the fast quark(s)) must interact with the string. At the same time these string production processes leading to a shock confinement in transverse plane of the reaction. As a consequence the strings formed in the interactions of the string parton with the quark(s) occur strongly overlapped in the impact parameter. This leads to the appearance of the string production due to string fusion processes. As known, these processes lead to the additional production of heavy flavor such as B, K for the case of cumulative strange production. Along with the usual strangeness-limited version of a string fragmentation we consider also the modified version leading to the thermal-like spectra [2,4], what results in the increased production of strange and heavy flavour particles [3,4].

Summary:

1) So in this approach based on the combination of two complementary models (flucton cumulative fragmentation + string fusion) we can expect the positive correlation between production of particle in the backward cumulative region and relative yield of heavy flavors in forward direction.
2) The non-perturbative contribution to the production of heavy flavour particles, due to the additional string fusion effects in fluctuation region, can be more noticeable at small initial energies in fix target pA experiments, as in discussed future experiments with modified NA61 at SPS. We also expect that this contribution will manifest itself more clearly in colliders with high jet (gluon, pion), because of the absence of other strange-fusion effects.

The work was supported by the RFBR grant 18-02-40075 and by the Saint Petersburg State University outgoing academic mobility grant id 40214007.