PROCEEDINGS OF SCIENCE

Study of final states in p-Au and p-Pb collisions

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In the framework of PYTHIA8.2 program we considered p-Pb and p-Au heavy ion collisions at the energy of 5.02 TeV and 8 TeV. This program combines several nucleon-nucleon collisions into one heavy ion collision, based on phenomenological treatment of a hadron as a vortex line in a colour superconducting medium, and treats consistently the central rapidity region with improvements of Glauber-like model where diffractive excitation processes are taken into account. We considered the influence of impact parameter correlations on the particle production cross sections in p-Pb and p-Au collisions to estimate the influence of hard and soft subprocesses on basic hadronic final-state properties in proton-ion collisions. Using these characteristics based on semi-hard multiparton interaction model we received the transverse momentum and rapidity distributions of K-meson and Λ-baryon at the energy of 5.02 TeV and 8.14 TeV.

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1. Introduction

Studying the few-body hard-scattering processes leading to complex multiparticle final states is one of the interesting goals of high energy physics. In addition to the standard basic processes there will be internal processes, involving parton showers, processes with extra dimensions, supersymmetric processes and more new states. To understand the underlying events in hard processes QCD Monte-Carlo models are most usefull for modeling data behavior.

We will concentrate on QCD hard processes in pp, p-Pb and p-Au collisions with higher final-state multiplicity, which include soft- and hard-QCD processes. If low-mass diffractive systems are represented as non-perturbative hadronizing strings, then for diffractive systems with masses about 10 GeV, multiparton interactions (MPI) - multiple interactions between several pairs of incoming partons presented by initial-state radiation (ISR), final-state radiation (FSR), and string fragmentation are included.

One of the models describing the characteristics of the nucleus-nucleus interactions connected with the calculations of the number of interacting nucleons and binary NN collisions is the Glauber model [1]. This formalism is based on the eikonal approximation in impact parameter space, where the incident particle sequentially interacts with the nucleons of the target nucleus through multiple sub-collisions. Using assumption about the matter distribution in the colliding protons, the cross section gets a relative probability for each additional sub-scattering. All partonic sub-collisions are treated as separate QCD $2 \rightarrow 2$ scatterings. To eliminate divergences of the cross section at low $p_{\perp}$ was used a parameter $p_{\perp 0}$ which depends on the collision energy.

Recent precise measurements at the LHC show the following: flow-like effects in pp and p-nucleus collisions [2], strangeness and baryon rates increasing in pp events with high multiplicity [3], enhanced transverse momenta and rising of angular correlations expansion for high mass particles in high energy collisions allowing for rope formation [4]. These collective effects in nucleus collisions could possibly originate not from QGP formation but from non-thermal interactions between string-like colour fields with the dense configurations of confined QCD flux tubes with high string density. The Lund string model [5] described by a "massless relativistic string", presents flux tube with no transverse extension. Gluons are treated as point-like transverse excitations on the string [6], stretched from a quark via the colour-ordered gluons to an antiquark. The partons connected in strings then evolve in a partonic cascade after freeze-out, and hadronise according to the Lund model and then the obtained hadrons form a secondary cascade as free particles. The probability for a final state is given in Ref. [7].

2. Results of calculations

In the framework of PYTHIA8.3 program [8], the inclusion of Angantyr model for heavy ions [9] gave us the opportunity to make calculations of p-Pb and p-Au heavy ion collisions at the energy of 5.02 TeV and 8.14 TeV. This program combines several nucleon-nucleon collisions into one heavy ion collision, based on phenomenological treatment of a hadron as a vortex line in a colour superconducting medium and treats consistently the central rapidity region with improvements of Glauber-like model where diffractive excitation processes are taken into account.

We considered the influence of impact parameter correlations on the particle production cross sections in p-Pb and p-Au collisions to estimate the influence of hard and soft subprocesses on basic hadronic final-state properties in proton-ion collisions. Using these characteristics based on semi-hard multiparton interaction model we received the transverse momentum and rapidity distributions of K-meson and Λ-baryon at the energy of 8.14 TeV.

By comparing the results at 5.02 TeV and at 8.14 TeV we can conclude that the shape of these distributions is the same regardless of the collision energy with the exception of the number of events, which is natural. In addition, the number of events for the K meson is always greater than for the Λ-baryon, which is also natural, since the baryon is heavier than the meson.

We also calculated charged-particle multiplicity distributions for different impact parameter at the energy of 8 TeV. The results are in Fig. 1.

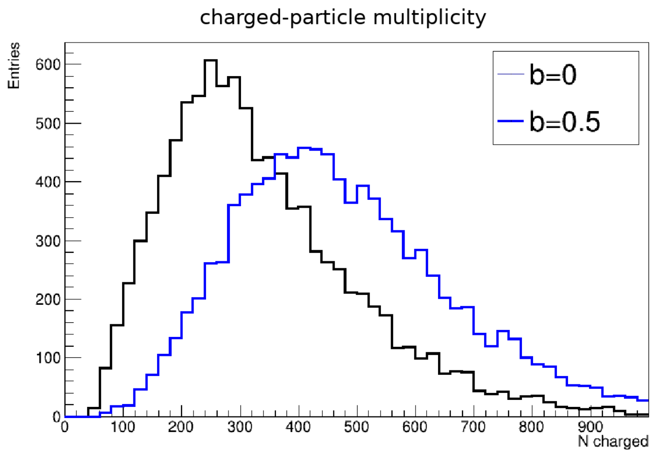

Fig. 1 Charged-particle multiplicity distributions at 8 TeV for p-Au collisions for different impact parameters.

By comparing the number of events for the charged-particle multiplicity distribution, we see that the distribution peak decreases and shifts right with an increase in the impact parameter from 0 to 0.5. Inclusion of initial- and final-state interactions in the model leads to higher particle multiplicities.

To study the effect of subprocesses during proton-proton interactions on the total production cross section, we performed calculations at 8 and 13 TeV which allows us to say that the pp interaction cross section increases with energy and there is a redistribution of the fraction of gluon-gluon and quark-antiquark processes with the formation of charm quark-antiquark and light quark-antiquark pairs, respectively at 13 TeV. In addition, we can conclude that non-diffractive processes contribute more to the overall particle production than elastic and double-diffractive ones. The smallest fraction of the production cross section is accounted for by quark and gluon interactions.

3. Conclusions

We considered proton-proton and proton-ion (Pb, Au) collisions at the energies of 5.02 TeV and 8.14 TeV. Using PYTHIA 8.3 program with Angantyr model for heavy ions we calculated the transverse momentum and rapidity distributions for K-meson and Λ-baryon at the energy of 5.02

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TeV and 8.14 TeV. As a result we could conclude that there is the string influence on the p-ion interactions (production cross section larger for inclusion of strings) and no string influence on the pp interactions. Impact parameter is influencing on p-Pb, p-Au and p-p interactions, for b=0.5 particle production is higher than for b=0 for K-meson and Λ-baryon. K-meson production has symmetric rapidity distribution, but for the Λ-baryon production it is asymmetric in the backward direction. Hard processes contribute less in comparison with non-diffractive processes.

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