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Elliptic flow in ultrarelativistic heavy-ion collisions

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Abstract

This project aims to act as an introduction to the field of high-energy particle physics through the study of theories, models and simulations used to understand experimental results from the LHC, such as event generators and simulators that reproduce heavy-ion's collision chain. Physical processes such as fragmentation and the production of jets, ultrarelativistic hydrodynamics and statistical hadronization models will be employed in this research, and the final goal is to compare the results with measurements from the ALICE collaboration.

Key words:

Hadronic phase, LHC, Ultrarelativistic hydrodinamics.

Introduction

The extreme conditions obtained when colliding ultra-relativistic heavy-ions at modern particle accelerators lead to the formation of strongly interacting matter in which partonic degrees of freedom become relevant. This state of matter is called a Quark-Gluon Plasma (QGP). A full theoretical description of the systems created in such collisions is an open challenge in the field of high-energy nuclear physics. The most common description treats the various stages of system evolution using different approaches. In these models, the system undergoes a QGP phase that is simulated using relativistic hydrodynamics and, after it has expanded and cooled down enough, it then hadronizes via sampling of the energy-momentum hypersurface. The resulting hadrons are then still left to interact both elastically and inelastically in a hadronic phase simulated using hadron cascade models, such as UrQMD, until hadron densities are low enough that no further interactions will occur. Because such models utilize several physical assumptions and components to calculate final-state hadrons, they are called *hybrid models*.

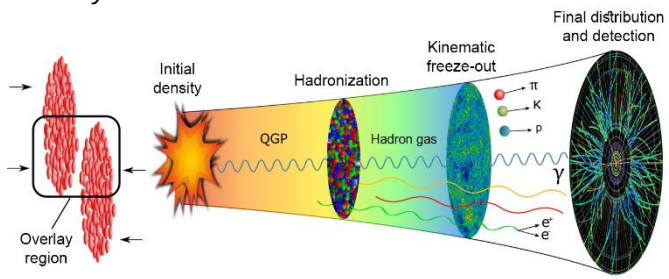

Figure 1. Representation of the steps in a ultrarelativistic heavy-ion collision. The overlay region defines the *centrality* of the collision, an important variable in the characterization of the hadronization process.

In this work, we intend to study the elliptic flow, v_2, of charged particles created in Pb-Pb collisions at the energies of $\sqrt{s_{NN}}$ 2.76 TeV and 5.02 TeV using a hybrid model that employs the MUSIC hydrodynamic simulator as well as UrQMD to emulate the hadronic phase. This final state v_2 will be compared to initial state conditions as well as to available experimental data from the ALICE collaboration.

Results and Discussion

As a first approach to the methodology necessary to the development of the research project, experimental observables and Monte Carlo algorithms of importance to the field, along the general theory of high energy particle collision[1], were studied, which forms a knowledge base that will be used thought the whole project.

The next step was then to generate plots of data using the TRENTo[2] initial condition generator and the ROOT data analysis framework. Those were compared to experimental data[3] from the ALICE collaboration, as shown below.

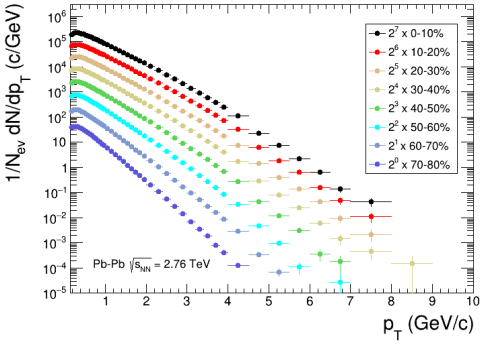

Figure 2. Plot of densities against transversal momentum, p_T, of the resulting particles for each centrality.

Conclusions

We have already calculated charged particle pT distributions from simulations at $\sqrt{s_{NN}}$ = 2.76 TeV. In the ongoing analysis, we will compare these predictions to ALICE data and also study further observables such as elliptic flow. The results will them be presented in the conference.

Acknowledgement

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[1] WONG, Cheuk-Yin. Introduction to high-energy heavy-ion collisions. Singapore: World Scientific, **c1994**. 516 p.;

[2] For more information, see http://qcd.phy.duke.edu/trento/;

[3] The ALICE collaboration, Transverse momentum spectra and nuclear modification factors of charged particles in pp, p-Pb and Pb-Pb collisions at the LHC. JHEP 1811 (2018) 013, available at https://doi.org/10.1007/JHEP11(2018)013