Hessisches Kompetenzzentrum
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ALICE Experiment - The Search for Signatures of the Quark-Gluon Plasma



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Project Areas
Optics, Quantum Optics and Physics of Atoms, Molecules and Plasmas

Clusters
LOEWE CSC Cluster Frankfurt

Institute
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Introduction

The group participates in the ALICE experiment at the Large Hadron Collider (LHC) at CERN. The research activities focus mainly on the search for signatures of the quark-gluon plasma (QGP), a state of matter in which quarks and gluons, the elementary constituents of hadronic matter, can be regarded as quasi-free particles. Measuring the properties of the QGP does not only extend our understanding of these elementary particles and their interactions, but also provides important input for cosmological models, as the QGP is believed to have existed during the early stage of the universe.

Methods

For the understanding of the QGP produced in heavyion collisions studying small systems like the collisions of two protons (pp) where no QGP is present constitutes an important baseline experiment. We employ the Loewe-CSC cluster resources to analyze aggregated data, test new analysis software and, most of all, run simulations with high statistics.

Two Bachelor students, two Master students, eight Ph.D. students and two Postdocs from the group are working on the cluster. Due to the large size of data samples recorded by ALICE and other LHC experiments, most of the analysis activities are run distributed on the LHC-Grid. The Loewe-CSC is part of this worldwide computing grid. It also provides the possibity to test the analysis software locally on subsamples of the data on short

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time scales, which is crucial for large-scale analyses.

Results

In the following, selected analyses using the Loewe-CSC resources will be explained. A possible QGP signature studied in both pp and heavyion collisions is the fluctuation of the mean transverse momentum from event to event. For these analyses, several simulations of 100 million pp events each have been performed at the Loewe-CSC. Two simulations have been used for comparison to ALICE data in (Abelev et al.) [1].

Recently, further simulations have been performed within a bachelor thesis. [2] The measurement of the transverse momentum spectrum of charged particles measured in p-Pb collisions adds complementary information to the same measured observable in Pb-Pb collisions. By comparing these spectra in p-Pb and Pb-Pb collisions to spectra measured in pp collisions, especially at high transverse momenta, potential collective effects can be disentangled from the underlying particle production described by perturbative calculations.

The Loewe-CSC has been used to simulate charged-particle spectra under the condition that the Electromagnetic Calorimeter (EMCal) of ALICE has selected events based on the deposited energy in the EMCal. The extension of inclusive charged-particle spectra to high transverse momenta and their possible modification based on such a selection have been studied within a bachelor thesis using these simulations. [3]

Discussion

The ALICE experiment is preparing for a major detector upgrade for the future LHC run 3 that is expected to start in 2020. Extensive feasibility studies on the main physics goals have been performed to motivate and strengthen the need for this upgrade. [4] The simulations for this upgrade for the measurement of low-mass dielectrons have exclusively been run at the Loewe CSC. Using the planned detector upgrades for the ALICE Inner Tracking System ITS and the ALICE Time Projection Chamber, 20 million pp events including realistic detector response were simulated for three different magnetic field settings at the Loewe-CSC. Based on the analysis of these simulated events it was concluded that the temperature of the QGP becomes in reach to be extracted using the measurement of dileptons after the ITS upgrade. The results of these simulations entered the technical design report of the upgraded ITS [5] and a master thesis [6] is based on this analysis.

Outlook

In the next years the group plans to use the Loewe-CSC to calculate contributions from particle decays to the invariant mass spectrum of dileptons (cocktail calculation). Furthermore, it is planned to intensify the study to evaluate the impact of EMCal triggers on the inclusive charged-particle spectra to extract a

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trigger efficiency.

Reference

[1] B. Abelev et al. (2014), (ALICE Collaboration), Event-by-event mean pT fl uctuations in pp and Pb-Pb collisions at the LHC, Eur. Phys.J. C74, 3077. https://doi.org/10.1140/epjc/s10052-014-3077-y

[2] B. Schütz (2014), Bachelor thesis: Monte-Carlo-Studien zum Einfluss von Multi-Parton-Interaktionen auf die Fluktuationen des mittleren Transversalimpulses in pp-Kollisionen, Institut für Kernphysik, Goethe-Universität, Frankfurt.

[3] P. Huhn (2015), Bachelor thesis: Studie zur Triggereffizienz geladener Teilchen in ALICE, Institut für Kernphysik, Goethe-Universität, Frankfurt.

[4] B. Abelev et al. (2012), (ALICE Collaboration), Upgrade of the ALICE Experiment Letter of Intent, CERN-LHCC-012-012 / LHCC-I-022. http://dx.doi.org/10.1088/0954-3899/41/8/087001

[5] B. Abelev et al. (2014), (ALICE Collaboration), Technical Design Report for the Upgrade of the ALICE Inner Tracking System, J. Phys. G 41, 087002. http://dx.doi.org/10.1088/0954-3899/41/8/087002

[6] C. Klein (2014), Master thesis: Studie zum Einfluss der Teilchenidentifizierung mit dem ALICE-ITS auf die Messung von Dileptonen kleiner invarianter Masse, Institut für Kernphysik, Goethe-Universität, Frankfurt.

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