# HK 24: Heavy-Ion Collisions and QCD Phases V

Time: Wednesday 14:00–16:00 Location: J-HS F

**Group Report** HK 24.1 Wed 14:00 J-HS F

**Latest flow results and new developments in the flow analyses techniques** — •Ante Bilandzic for the ALICE-Collaboration — Technical University of Munich, Germany

With the advent of large statistics heavy-ion datasets at RHIC and LHC, comprising particularly events with the very large number of produced particles, it is becoming feasible to study the properties of Quark-Gluon Plasma with unprecedented precision. One of the most informative probes in such studies is the collective anisotropic flow, which can be measured very reliably with multiparticle correlation techniques in an environment characterized with large multiplicities and large values of flow harmonics.

In this group report we present an overview of latest flow results, which include: First ALICE results for the recently developed flow observables dubbed higher order Symmetric Cumulants, new analysis technique for the measurement of symmetry plane correlations, development of new hydro-based model to explain "flow-like" signals in pp collisions, study of universal non-flow scaling in azimuthal correlators, feasibility study for the usage of multiparticle correlations in flow analyses at CBM experiment, and finally, update on the status of applying multiparticle correlations in femtoscopy.

HK 24.2 Wed 14:30 J-HS F

**Symmetry-plane correlations in flow analyses in ALICE** — •Marcel Lesch for the ALICE-Collaboration — Technische Universität München, Germany

The study and experimental analysis of collective phenomena in heavy-ion collisions are nowadays to a great extent built on the so-called flow amplitudes $v_n$ and symmetry-planes $\Psi_n$. Both appear as two distinct degrees of freedom in the Fourier series expansion which is used to parametrize the distribution of azimuthal angles of produced particles in high-energy nuclear collisions. Using multiparticle correlation techniques, the studies of flow amplitudes $v_n$ and correlations amongst them have seen a lot of advancements over the past years.
In this talk, we address the complementary degrees of freedom by summarizing recent developments in the direction of symmetry-plane correlations (SPC) and the introduction of new observables for their measurement. We provide predictions of these observables for the initial coordinate space with the MC-Glauber model and for the final momentum space by iEBE-VISHNU for Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$. Finally, we present the first experimental results of SPC measured with these new observables using ALICE data for Pb–Pb at $\sqrt{s_{\mathrm{NN}}} = 2.76\,\mathrm{TeV}$ (2010).

HK 24.3 Wed 14:45 J-HS F

**ALICE studies of the particle-species dependent anisotropic flow with spectators** — •Michael Ciupek for the ALICE-Collaboration — Physikalisches Institut, Heidelberg, Deutschland — GSI Helmholtzzentrum für Schwerionenforschung, Darmstadt, Deutschland

In relativistic heavy-ion collisions, the initial energy density in the overlap region of the colliding nuclei is asymmetric. Due to interactions, this asymmetry is transferred to the momentum distribution of particles in the final state. The measurement of the anisotropic flow relative to the spectator plane is of special interest since the spectators decouple very early from the collision and are sensitive to the spatial shape of the initial energy density distribution.
The thermodynamic expansion of the quark-gluon plasma (QGP) results in a mass ordering of the anisotropic flow of particles as function of the transverse momentum. As such, the anisotropic flow of identified particles with respect to the spectator plane is sensitive to the three-dimensional evolution of the QGP. Additionally, the difference of the anisotropic flow of particles and anti-particles, such as protons and anti-protons, allows investigating the transport of different quantum numbers (e.g. baryon number) in the QGP.
In this talk, studies of the particle-species dependent anisotropic flow with respect to spectators in Pb-Pb collisions with ALICE are presented. The particle identification is performed using a Bayesian approach, combining the information from different detectors. The spectator plane is reconstructed with the Zero Degree Calorimeter.

HK 24.4 Wed 15:00 J-HS F

**First measurements of multi-harmonic correlations in ALICE** — •Cindy Victorine Simone Mordasini for the ALICE-Collaboration — Technische Universität München (DE)

Genuine multiparticle azimuthal correlations have shown their usefulness to study and constrain the properties of the Quark-Gluon Plasma (QGP). Recently introduced, the measurements of the correlated fluctuations between two different flow amplitudes using Symmetric Cumulants have exhibited a better sensitivity to the transport properties of the QGP than the studies of single flow amplitudes.

The question of the genuine correlations between more than two flow amplitudes has then arisen. Their measurements can bring new and independent constraints on the system produced in heavy-ion collisions. In that respect, a generalisation of the Symmetric Cumulants has recently been proposed. This new set of observables is sensitive only to the genuine correlations between three and more flow amplitudes and has been named higher order Symmetric Cumulants.

In this talk, we present the first experimental results of these new higher order multi-harmonic correlations using data collected by ALICE in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 2.76$ TeV. We will address their potential to provide new insights on the origin of the correlations between the flow amplitudes. We will show comparisons with state-of-the-art hydrodynamic models as well.

HK 24.5 Wed 15:15 J-HS F

**CBM performance for charged hadron flow measurements** — •Viktor Klochkov[1,2] and Ilya Selyuzhenkov[1,3] for the CBM-Collaboration — [1]GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany — [2]Goethe Universität Frankfurt, Frankfurt am Main, Germany — [3]National Research Nuclear University (Moscow Engineering Physics Institute), Moscow, Russia

The Compressed Baryonic Matter experiment (CBM) at FAIR aims to study the area of the QCD phase diagram at high net baryon densities and moderate temperatures using collisions of heavy ions at center-of-mass energies of a few GeV per nucleon. Anisotropic transverse flow is among the key observables to study the properties of matter created in such collisions. The CBM performance for anisotropic flow measurements is studied with Monte-Carlo simulations using gold ions at SIS-100 energies with lab momentum up to 12A GeV/c employing different heavy-ion event generators. Various combinations of CBM detector subsystems are used to investigate the possible systematic biases in flow measurement and to study the effects of detector azimuthal non-uniformity. The resulting performance of CBM for flow measurements is demonstrated for different harmonics of identified charged hadron anisotropic flow as a function of rapidity and transverse momentum in different centrality classes.

HK 24.6 Wed 15:30 J-HS F

**Collective flow measurements with HADES in Au+Au collisions at 1.23 AGeV** — •Behruz Kardan — Goethe-Universität, Frankfurt am Main

HADES provides a large acceptance combined with a high mass-resolution and therefore allows to study dielectron, hadron and light nuclei production in heavy-ion collisions with unprecedented precision. The high statistics measurements of flow coefficients for protons and light nuclei including $^3$He and $^4$He in Au+Au collisions at 1.23 AGeV are presented here. In addition to the directed ($v_1$) and elliptic ($v_2$) flow components also the higher coefficients $v_3$ and $v_4$ are investigated for the first time in this energy regime. All flow coefficients are studied multi-differential for different centrality classes over a large region of phase space, i.e. as a function of transverse momentum $p_t$ and rapidity. We will discuss the scaling properties of the varios flow harmonics as function of $p_t$, rapidity and centrality. This provides the possibility to characterize the production process of light nuclei, i.e. via coalescence, and puts strong constraints on the determination of the properties of dense matter, such as its viscosity and equation-of-state (EOS).

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HK 24.7 Wed 15:45 J-HS F

**Confronting the fluid description of extreme QCD matter with experimental data from RHIC and the LHC** — •Damir Devetak[1], Andrea Dubla[2], Stefan Floerchinger[3], Eduardo Grossi[3], Silvia Masciocchi[1,2], Aleksas Mazeliauskas[4], and Ilya

Selyuzhenkov[2] — [1]Physikalisches Institut, Universität Heidelberg — [2]GSI Helmholtzzentrum für Schwerionenforschung — [3]Institut für Theoretische Physik, Universität Heidelberg — [4]Theoretical Physics Department, CERN

In heavy-ion collisions at relativistic energies, QCD matter reaches extreme conditions in terms of temperature and energy density. Its space-time evolution is successfully described within a framework of relativistic fluid dynamics. A new efficient and flexible computational framework to solve the fluid equations will be discussed. In this contribution, detailed comparison to experimental data on identified charged particle production in nucleus-nucleus collisions at RHIC and the LHC energies, differentially in event centrality and the particle momentum will be presented. The speed and flexibility of our calculations, together with the high precision of recent experimental measurements, allow to extract fundamental properties of hot and dense deconfined QCD matter such as its transport coefficients and freeze-out temperature. We also investigate tensions between experimental data and the fluid description, which forms a platform for testing new hypotheses.