EPJ Web of Conferences **271**, 08011 (2022) https://doi.org/10.1051/epjconf/202227108011
HYP2022

Kaon flow in Au+Au collisions at 1.23AGeV measured with HADES

Lukáš Chlad[1,2,*] for the HADES collaboration

[1]Nuclear Physics Institute of the CAS, Řež 130, 25068 Husinec, Czech Republic
[2]Faculty of Nuclear Sciences and Physical Engineering, CTU in Prague, Břehová 7, 11519 Praha, Czech Republic

Abstract. We present results on the anisotropic transverse flow of kaons (K^+, K_S^0 and K^-) in Au+Au collisions at $\sqrt{s_{NN}} = 2.42$ GeV measured with HADES. It was proposed already in the mid-nineties that kaon flow close to its production threshold might be a good probe for the kaon-nucleon potential and, consequently, for the nuclear equation-of-state. The presented analysis was performed on more than 2 billion events of the 40% most central collisions, which opened the possibility of analyzing the kaon flow differentially as a function of transverse momentum, rapidity, and centrality, even in this low-energy regime. The measurements are compared to microscopic transport model predictions and to other data at similar collision energies. Implications on the properties of compressed nuclear matter will be discussed.

1 Introduction

To understand the properties of hot and dense matter that exists during merger of neutron stars [1], a study of strange hadrons and namely kaons was suggested [2]. A particular interest to study transveral flow was proposed in [3] which resulted in many experiments like KaoS [4] and FOPI [5]. The lack of detailed differential measurements below and near the kaon production threshold demands further investigation, which is partially presented in this contribution.

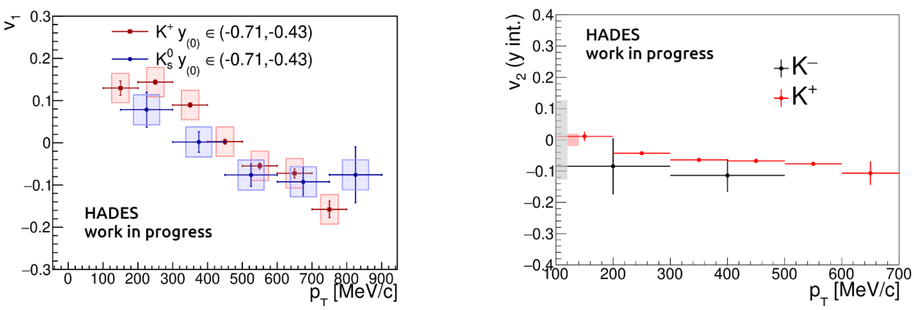
The presented analysis was performed on data collected by the HADES Collaboration during spring 2012 when accelerated gold ions with kinetic energy 1.23*A* GeV interacted with a fixed segmented gold target. From the acquired data set, more than 2 billion events with centrality up to 40% were selected. HADES spectrometer consists of diamond based t_0 detector followed by RICH hadron blind detector. Particles are futher travesing multiwire drift chambers (two in front and two behind a toroidal magnetic field) and are finaly detected by time-of-flight wall (made of RPC detector at lower polar angles and scintillator based TOF array for larger θ angle), for more details see [6]. Further behind this setup is a scintillator-based forward wall, which is used to determine the angle of the event plane [7].

Specific energy losses of charged kaons are used for their identification together with the track quality criteria [8]. The short-lived neutral kaons are reconstructed via their decay into charged pions (identified via velocity and momentum correlation) with pair selection based on the decay topology variables [9]. Residual backgrounds in the invariant mass spectra is described by mixed-event technique for K_S^0 and by cubic fit function for charged kaons.

*e-mail: chlad@ujf.cas.cz

2 Results

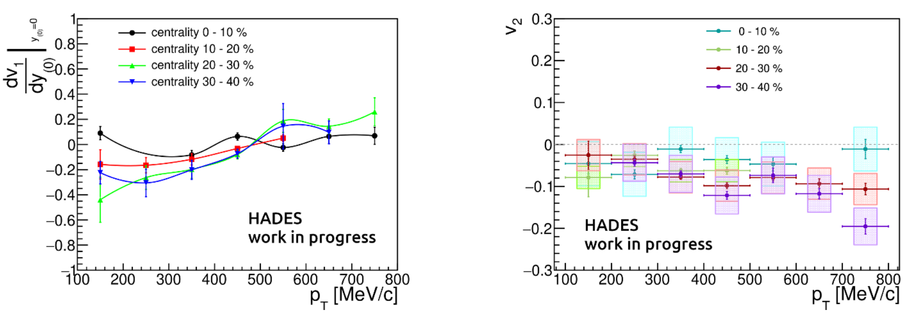
Using the kaon identification described above and the transverse flow analysis technique summarized in [7] we were able to obtain the following results. There is no significant difference in observed flow of K^0_S and K^+, see figure 1a, which can be anticipated as they both contain strange antiquark. Moreover, there is indication of similar behavior of K^- as well (in figure 1b) which is rather unexpected taking into account very different potentials between nucleons and kaons versus antikaons. However, from our measurement we obtained large uncertainties for negative kaons and there is also a significant ratio of antikaons coming from ϕ meson decay [8] that can influence observed flow. We observe a strong dependence of kaon flow with respect to transverse momentum, see Figure 2a as well as decreasing absolute strength of flow in the most central collisions, see Figure 2.



(a) directed flow of K^+ and K^0_S

(b) elliptic flow of K^+ and K^-

Figure 1: Comparison of transverse flow for different kaon's charges.



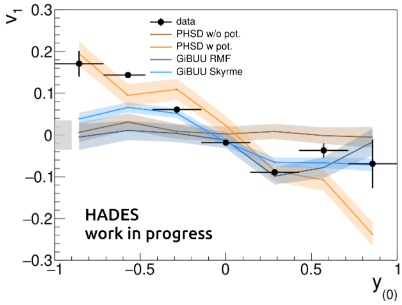
(a) slope of v_1 at midrapidity

(b) rapidity integrated v_2

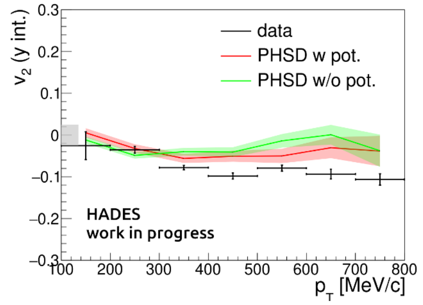
Figure 2: Centrality dependence of transverse flow of K^+.

3 Comparison with predictions of kinetic transport models

Multiple kinetic transport model predictions were studied to have a first insight into which aspects of kaon creation and propagation in dense matter influence their directed and elliptic flow. Only a few selected results are presented here. We observed that pure so-called cascade models do not predict non-zero v_1 or v_2 which is in contrast to our measurements. Better agreement was achieved with models that are using some form of (anti-)kaon nucleon potential as one can see from figure 3. It is clearly visible that our measurements prefer the PHSD model with the inclusion of V_{KN} over the option without potentials. It is clear that more detailed comparison with kinetic transport models as well as further precise measurements (for example HADES Ag+Ag at 1.56*A* GeV performed in spring 2019) are necessary to make any strong conclusions.



(a) v_1 for low p_T



(b) rapidity integrated v_2

Figure 3: Comparison of model predictions for transverse flow of K^+ for 20 – 30% most central collisions.

Acknowledgement

Work supported by: NPI CAS, Rez, Rez (Czech Republic), MSMT LTT17003, MSMT LM2018112, MSMT OP VVV CZ.02.1.01/0.0/0.0/18_046/0016066.

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