K^+ Flow in Heavy Ion Collisions at SIS Energies

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Experimental data on K^+ sideward flow measured with the FOPI detector at SIS/GSI in the reactions $Ni+Ni$ at 1.93·A GeV and $Ru+Ru$ at 1.69·A GeV are presented. They are compared to different transport model predictions investigating the effects of in-medium modification of kaon properties.

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1. Introduction

The collective flow of baryons in heavy ion collisions which has been extensively studied over the two last decades in both experimental data and transport-model theories, is recognized as a useful observable to probe the nuclear equation of state at high densities [1]. Recent theoretical works suggest that the flow not of baryons but of produced strange particles such as kaons and lambdas is of great interest since it should carry information about hadron properties in hot and dense nuclear matter. In particular, the flow of charged kaons was predicted to be sensitive to a change of kaon masses in dense matter driven by a possible partial restoration of the chiral symmetry in the nuclear medium [2].

2. K^+ flow in Ni+Ni at 1.93·A GeV

The first experimental data on K^+ sideward flow (*e.g.* in reaction plane flow component) have been obtained by the FOPI Collaboration in Ni+Ni reactions at 1.93·A GeV [3]. The results are displayed in Fig. 1 in terms of the mean in-plane transverse momentum divided by the particle mass as a function of the rapidity ($y^{(0)}$ is the particle rapidity divided by the projectile rapidity in the centre-of-mass system). It is observed that protons exhibit the well-known shape characterising an in-plane collective deflection whereas

K^+ show a vanishing flow *i.e.* a signal compatible with zero. As depicted by the full curves of Fig. 1, this experimental trend clearly supports an in-medium potential scenario for K^+ thus implying the existence of a repulsive K^+-nucleon mean field. However an alternative description of the data was proposed in [4] invoking rescattering effects instead of in-medium kaon potentials. In addition, the sensitivity of K^+ sideward flow to in-medium effects was found in [5] to be washed-out when a momentum dependence of the potential is included in the calculations. At last, it was recently pointed-out in [6] that the life time of nuclear resonances used in the models is partially responsible for the magnitude of the K^+ sideward flow as it is a crucial ingredient for kaon production channels.

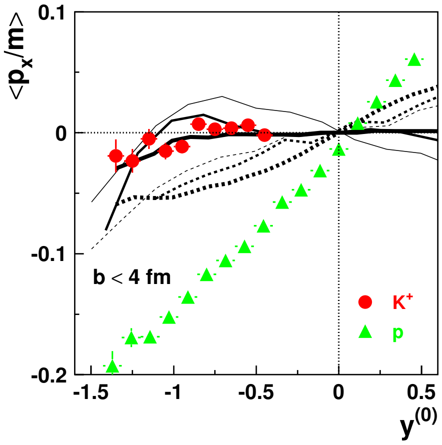

Figure 1 : Sideward flow of protons (triangles) and K^+ (circles) in central Ni+Ni reactions at 1.93·A GeV. Data (from [3]) are compared for K^+ to the calculations from [7] (thick curves), [8] (medium thick curves) and [9] (thin curves) with (full curves) and without (hashed curves) in-medium effects. Error bars represent statistical uncertainties.

3. K^+ flow in Ru+Ru at 1.69·A GeV

In order to further elucidate this questions, the Ru + Ru system at 1.69·A GeV has been investigated recently. Such a heavy system is well suited for flow studies since flow effects are larger as compared to lighter systems. It allows in addition to study K^+ flow in non-central collisions where, due to a large sensitivity of the observable to in-medium effects, an anti-flow phenomenum is expected to be seen [10, 11] (Fig. 2).

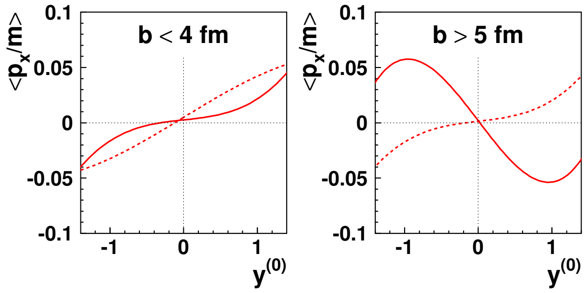

Figure 2 : Model predictions [10] for K^+ flow in Ru+Ru collisions at 1.69·A GeV with (solid curves) and without (hashed curves) in-medium effects (b is the reaction impact parameter).

Preliminary experimental results on the centrality dependence of the K^+ flow in Ru+Ru reactions at 1.69·A GeV are shown in Fig. 3.

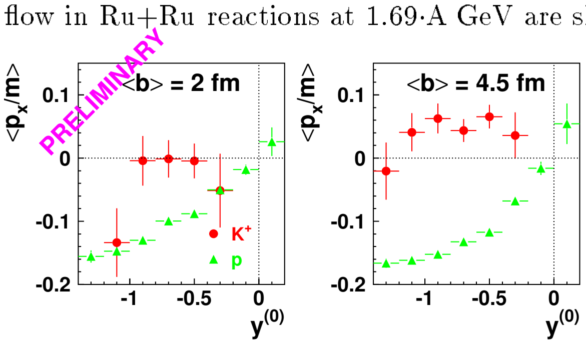

Figure 3 : Flow of K^+ (circles) and protons (triangles) in central (left) and semi-central (right) Ru+Ru events at 1.69·A GeV. Error bars represent statistical uncertainties.

The events were centrality selected by imposing cuts on the multiplicity of charged particles, PMUL, detected in the forward Plastic Wall of the FOPI detector. For the most central sample an additional condition on the global quantity ERAT [1] was applied. The reaction plane was reconstructed event wise, with an accuracy of about 40°. The results have been corrected for finite number fluctuations. A clear change in the K^+ flow pattern can be observed from a close-to-vanishing signal in central collisions to an anti-flow in semi-central collisions. This trend is in qualitative agreement with the model predictions shown in Fig. 2 when in-medium modification of the K^+ properties are taken into account. Although the change in the K^+ flow pattern between central and semi-central collisions is obvious, a quantitative statement about the magnitude of the signal is difficult at the present status of the analysis. The latter was found to depend somewhat on the applied quality criteria for the tracks in the main drift chamber and their matching with the time of flight system. Further analysis is in progress.

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