Revisiting hadron production at SIS energies using new HADES data *

M. Lorenz †1,2, T. Scheib2, H. Schuldes2, and the HADES collaboration* 
† University Utrecht, Netherlands; ‡ GU, Frankfurt, Germany

We present preliminary results on the production of hadrons with strangeness content \((K^+, K^-, K^0, \Lambda\) and \(\phi\)) in Au+Au collisions. At the measured center of mass energy of \(\sqrt{s} \approx 2.4\) GeV all hadrons carrying strangeness are produced below their free nucleon-nucleon threshold. While the \(K^-/K^+\) ratio nicely fits the trend observed at higher energies, we find a strong rise of the \(\phi/K^-\) ratio.

The data taking took place in April/May 2012. The read-out was started with a multiplicity trigger, running with an average rate of 8 kHz during the spills. The total data sample corresponds to \(7.3 \times 10^9\) events. Reconstructed tracks pass a track selection based on several quality parameters delivered by a newly developed high density tracking algorithm. Afterwards, hadrons are identified using the time-of-flight measurement.

In order to minimize systematic errors due to efficiency corrections and extrapolations in rapidity, we build ratios of the corrected yields at mid-rapidity for various hadron species which feature a comparable width in rapidity. The resulting \(K^-/K^+\) ratio can be directly compared to the previously obtained systematics at similar energy, without correcting for the different centrality selections of the various experiments, as both kaons experience a similar \(A_{\text{part}}\) dependence [1]. The measured ratio \(K^-/K^+\) fits into the trend observed at slightly higher energies and extrapolated down to the beam energy of 1.23 A GeV.

An interesting observable is the \(\phi/K^-\) ratio: It shows a flat trend at high energies, and is experimentally observed to rise towards lower energies [2]. This rise can be reproduced in the framework of the statistical model, if the suppression of strangeness is handled by introducing a strangeness correlation radius \(R_c\), within which strangeness has to be exactly conserved [3]. It is important to realize that, as the \(\phi\) conserves strangeness by definition, it is not suppressed by the strangeness correlation parameter in contrast to the other particles containing strange quarks.

We simultaneously fit the \(\pi^-/p, K^+/\Lambda, K^-/K^+\) and the \(\phi/K^-\) ratio using the freely available statistical model THERMUS [4]. Similar as for our fit to the Ar+KCl data sample [5] we constrain the charge chemical potential \(\mu_Q\) using the ratio of the baryon and charge numbers of the collision system, conserve the baryon number on average via the chemical potential \(\mu_B\) and calculate strangeness canonically by introducing the additional sub volume defined by \(R_c\). As we are restricted to ratios we fix the radius of the fireball \(R\) arbitrarily to 3 fm. In this way we find the chemical freeze-out at a temperature of \(T_{\text{chem}} = (47 \pm 5)\) MeV and at a baryochemical potential of \(\mu_b = (799 \pm 22)\) MeV. The ratio \(R_c/R\) is determined to \(0.3 \pm 0.2\) while the \(\chi^2/\text{d.o.f.}\) of the fit corresponds to 1.2. We note that our freeze-out point fits remarkably well to the result obtained in [6] for a similar system but restricted to fewer identified particles. Also \(R_c/R\) agrees within errors with the value obtained in our Ar+KCl fit of \(0.5 \pm 0.3\). Going from the medium-sized Ar+KCl system (measured at 1.76 AGeV) to the heavy Au+Au system the \(\phi/K^-\) ratio rises strongly. This effect is reproduced by statistical model calculations, using the above discussed parameters (especially \(R_c\)).

Figure 1: Comparison of hadron yields ratios of model and data, together with values obtained for the free parameters of the statistical model fit, see text for details.

References