RECENT RESULTS ON STRANGENESS PRODUCTION FROM CERN EXPERIMENT NA49

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New results from NA49 on the production of strangeness in elementary and nuclear reactions are presented. New measurements of charged kaon and pion production have been obtained from 40 AGeV Pb+Pb collisions. The evolution of strange meson yields in nucleus-nucleus interactions is studied as a function of collision energy and system size. Cascade baryon yields are presented for a wide range of hadronic interactions including first measurements in p+p and centrality controlled p+Pb collisions.

1 Introduction

NA49 is a large acceptance hadron spectrometer, which is designed to explore a wide range of hadronic interactions at different beam energies. The tracking system based on large TPC's allows a systematic study from elementary collisions such as p+p and π+p through the more complex p+A interactions to A+A interactions. A dedicated counter was designed to control the centrality of p+A collisions, whereas the system size dependence of A+A collisions can be studied by measuring C+C and Si+Si collisions from fragmentation beam. The experimental setup is described in detail in [1].

2 Strange Meson Yields in Nucleus-Nucleus Collisions

The main motivation to study A+A interactions is the search for the deconfined state. A signature of the onset of deconfinement would be the increase of the produced strangeness, measured by the ratio of kaons to pions.

2.1 Beam Energy Dependence

New results have been obtained in central Pb+Pb collisions at 40 AGeV beam energy for kaon and pion multiplicities [2]. Two independent analysis methods based on time of flight and specific energy loss (dE/dx) measurement are found to be consistent. The total yield per event measured in the 7% most central collisions is 56.3 ± 3 for positive and 17.8 ± 0.9 for negative kaons.

The energy dependence of the K^+/π^+ ratio is shown in Figure 1. The ratio of the total yields increases at AGS energies [4], shows a maximum around the 40 AGeV point and decreases slightly towards the top SPS energy. For comparison, the K^+/π^+ ratio in p+p collisions is also shown. The nonmonotonic behaviour is less pronounced for the yields measured at midrapidity. The analysis of last year's 80 AGeV beam and next year's 20 and 30 AGeV datataking will clarify the behaviour.
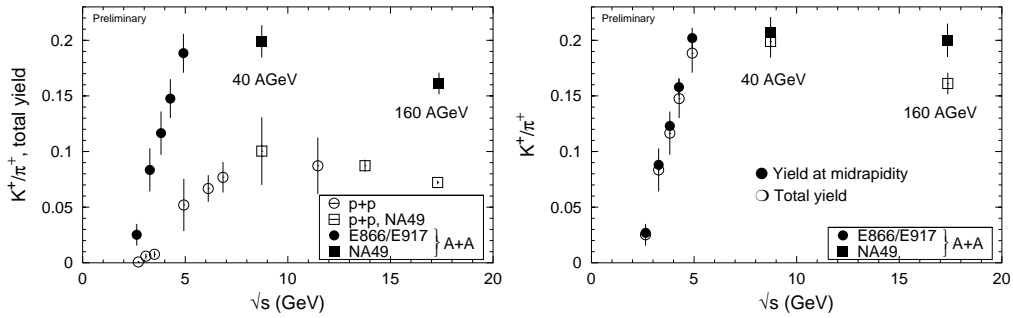
Figure 1: K^+/π^+ as a function of collision energy. (*Left:*) The ratio of total yields in A+A and p+p collisions. (*Right:*) Comparison of the ratio of total yields and midrapidity yields

2.2 System Size Dependence

In the search for the deconfined state, the other relevant initial parameter besides the beam energy is the size of the colliding nuclei. To study this dependence, C+C and Si+Si collisions were measured: Figure 2 shows the K^+/π^+ ratio compared to Pb+Pb and S+S measurements.
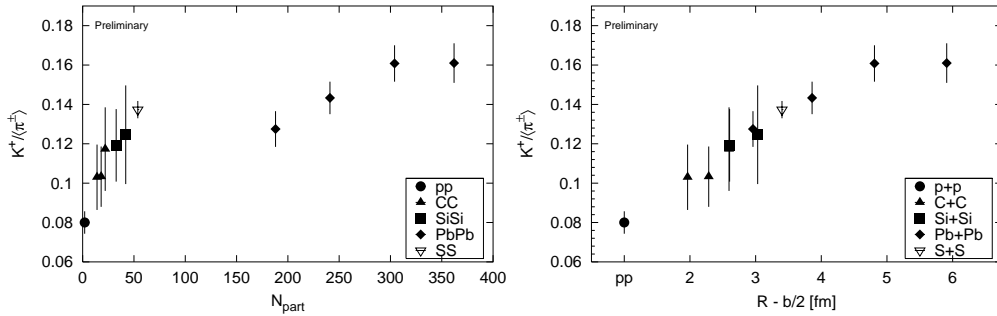

Figure 2: K^+/π^+ ratio at different system sizes, versus N_{part} (*left*) and versus $R - b/2$ (*right*)

The results clearly show that the number of participants (N_{part}) does not allow a common scaling for different system sizes and centralities. Instead of N_{part} another scaling variable can be invented [3]: plotting against $R - b/2$, where R is the radius of the nuclei and b is the impact parameter, the points fall on a uniform curve. This scaling variable corresponds to the width of the interaction zone. The analysis of the full available statistics will decrease the errorbars.

3 Cascade Baryon Production

The cascade baryons (Ξ^- and $\bar{\Xi}^+$) carry double strangeness, so they are more sensitive to strangeness production. The NA49 tracking system allows the measurement of these weakly decaying particles via their decay products [5][6]. The acceptance extends over a wide rapidity range (± 1 unit around midrapidity) and full transverse momentum range, from $p_T = 0$ up to 2 GeV. The centrality of p+A collisions is determined with a dedicated counter which detects the "grey protons", the recoil protons from the target. From that, using the VENUS model, the number of collisions (ν) can be determined. The centrality counter is also used for online triggering to enrich the more central sample.
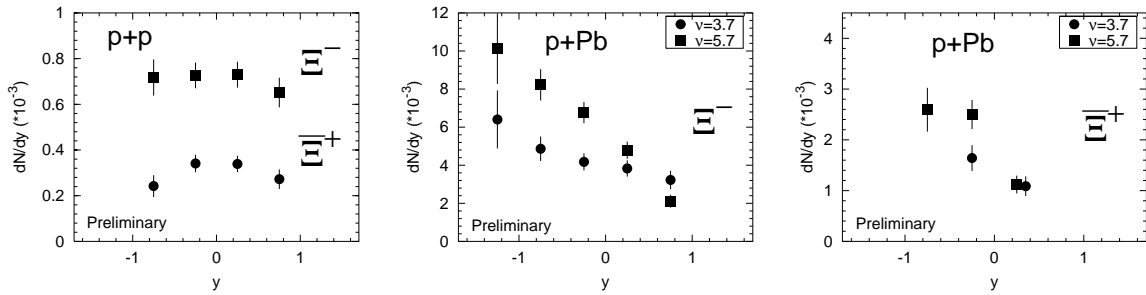
Figure 3: Cascade baryon yields in p+p (*left*) and in centrality controlled p+Pb collisions (*middle and right*)

3.1 Cascade Baryon Yields in Proton-Proton and Proton-Lead Collisions

Results on cascade baryon production [7] are shown in Figure 3. The p+Pb sample is divided into two subsets of different centrality, in which the mean number of collisions are found to be 3.7 and 5.7. The minimum bias p+Pb collision corresponds to $\nu = 3.75$. The baryon stopping effect is visible resulting in the decrease of the forward yield in more central p+A collisions.

3.2 Enhancement of Strange Baryons in Proton-Nucleus and Nucleus-Nucleus Interactions

The new measurements in p+p collision provide a new reference of elementary interaction for extrapolation to A+A collisions. Figure 4 compares the hyperon yields in p+p, p+A and Pb+Pb collisions at midrapidity, using the WA97 [8] and NA49 results.

The solid line on the figure corresponds to the simple Wounded Nucleon Model (WNM) prediction. An enhancement is visible in p+A, which means that the predicted scaling breaks already for p+A interactions.

3.3 Different Interpretations of the Enhancement

The WNM is a two component picture: both the target and the projectile sides deliver particles to midrapidity. The simplest assumption is that the yield is proportional to N_{part}. In case of p+A, when the projectile has undergone ν collisions, $N_{part} = \nu + 1$. This predicted scaling is indicated on Figure 4 with the solid line, using p+p as a reference. This scaling apparently breaks for p+A interactions, so it can not be used for extrapolation to A+A.

One can consider a simple modification [7] of the WNM: let's assume that in case of p+A, the target side delivers ν times half of the p+p yield (as does the target side of p+p), all rest of the observed yield comes from projectile fragmentation. From the measurement, the contribution of the projectile side can be determined in p+A. This gives a prediction for A+A at the same ν assuming that both sides of A+A behave as the projectile side of p+A. This prediction is shown on Figure 4 with the dashed line.

The difference between the conclusions of two oversimplified assumptions asks for a better understanding of p+A and A+A collisions. As the huge predicted increase of the yields compared to the WNM relied on a modest increase in p+A compared to p+p, precise measurements are also needed. Amongst others, one has to take into account the isospin-effect, arising from the neutron content of the nuclei; the question can be investigated by the analysis of last year's deuteron beam dataset. The other important effect is rescattering in the target, which can increase the target contribution.
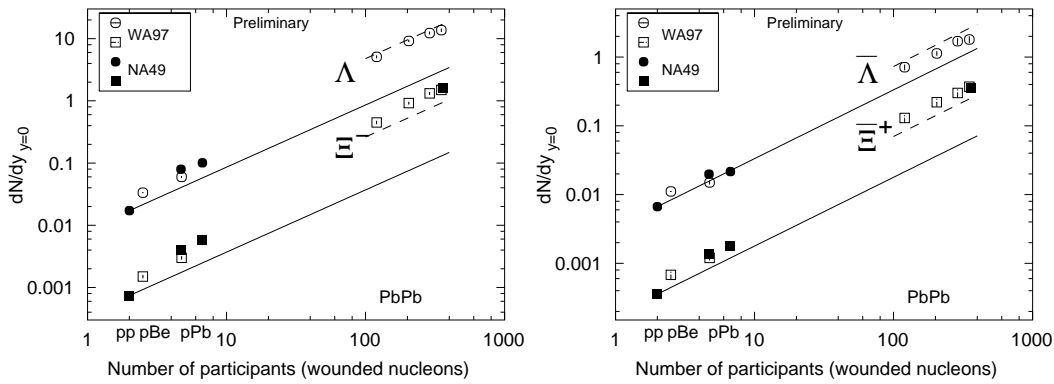
Figure 4: Midrapidity yields of hyperons in p+p, p+A and A+A collisions as a function of N_{part}

4 Conclusions

The new measurement at 40 AGeV beam energy indicates a non-monotonic behaviour of the K^+/π^+ yield in A+A collisions as a function of the beam energy. The upcoming results at 20, 30 and 80 AGeV will provide additional information. The study of the system size dependence revealed that the variable $R - b/2$ allows a common scaling unlike N_{part}.

The first results on cascade production in p+p collisions give a new reference for p+A and A+A collisions. The results show an enhancement in p+Pb compared to the simple WNM model, which makes the extrapolation to A+A collisions within this framework questionable.

Acknowledgements

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