Λ and φ Production in Heavy Ion Collisions

André Mischke for the NA49 collaboration
Gesellschaft für Schwerionenforschung, Darmstadt, Germany
present address: NIKHEF and University of Utrecht, The Netherlands
January 8, 2004

Abstract
Recent NA49 results on Λ and φ production in central Pb-Pb collisions at beam energies from 40 to 158 A-GeV are presented.

The measurement of strange baryons like Λ(uds), which contain between 30 and 60% of the total strangeness produced, allows to study simultaneously strangeness production and the effect of baryon density in A-A collisions. Essentially half of the s quarks are contained in K+. The φ meson consists of a s̅s pair, and should therefore be more sensitive than kaons and lambdas to the production mechanism in the early stage of the collision.

Since 1994 the NA49 collaboration has investigated hadron production in central Pb-Pb collisions at 158 A-GeV over a large range of rapidity and transverse momentum. Within the framework of the NA49 energy scan programme, started five years later, large data sets at lower energies (20, 30, 40, 80 A-GeV) have been recorded, for details see Ref. [1].

In the following, results on Λ hyperon and φ meson production in central Pb-Pb collisions at beam energies 40-158 A-GeV are presented. Starting from the reconstruction method we will focus on the energy dependence of the inverse slope parameter and the particle multiplicities.

In NA49, neutral strange and multi-strange particles are identified by the topology of the charged decay products, which are measured with the TPCs. The invariant mass distributions of Λ and Λ hyperons are given in Ref. [2]. The mass resolution (σm) of 2 MeV/c² is remarkably good. After corrections for acceptance and reconstruction efficiency the mT spectra and rapidity
Figure 1: The slope parameters $T$ for different particles (left) and the $\phi$ multiplicity ratios (right) as function of energy.

distributions were obtained from the raw data yields [2]. The left plot of Fig.1 shows the energy dependence of the inverse slope parameter $T$ of $\Lambda$ and $\bar{\Lambda}$, which exhibits a slight increase. This increase is also observed for protons, $\phi$ and deuterons. In contrast, the $\pi$ and $K$ slope parameter stays constant.

The total $\Lambda$ and $\bar{\Lambda}$ yields per event were obtained by integration of the distributions over rapidity and $p_T$ with only small extrapolations into unmeasured regions. The $\Lambda/\pi$ and $\bar{\Lambda}/\pi$ ratio from A-A and p-p collisions as a function of cms energy $\sqrt{s_{NN}}$ is shown in Fig.2, where $\pi = 1.5(\pi^+ + \pi^-)$. The $\Lambda/\pi$ ratio steeply increases at AGS energies, reaches a maximum and drops at SPS energies. Since $K^+$ carry the major fraction of the produced $\bar{s}$ quarks one expect the $K^+/\pi^+$ ratio to show a similar behavior as the $\Lambda/\pi$ ratio (using strangeness conservation) which is indeed the case [1].

The enhancement of strangeness production in heavy ion collisions compared to p-p is not a unique signature for the deconfined state, since this enhance-
ment is at low AGS energies, where a phase transition is not expected, about seven times higher than at top SPS energies \[3\]. Instead, rescattering processes like associated production $\pi N \rightarrow \Lambda K$ play an important role at lower energies.

In comparison to the energy dependence of $\Lambda$ production, the $\bar{\Lambda}/\pi$ ratio shows a monotonic increase similar to the $K^-/\pi^-$ ratio \[4\]. The measurements at 20 and 30 A·GeV will clarify whether there is also a structure like for the $K^-/\pi^-$ ratio. The differences in the excitation function of $\Lambda$ and $\bar{\Lambda}$ can be attributed to their different production mechanisms and the effect of net-baryon density. The transport models UrQMD and HSD as well as the statistical model reflect the main trend of the energy dependence of the $\Lambda/\pi$ and $\bar{\Lambda}/\pi$ ratio, except the UrQMD model for the $\bar{\Lambda}/\pi$ ratio. Since the lambda rapidity distributions are well described by the transport models the discrepancies can be attributed to the over-prediction of the pion multiplicities.

The $\phi$ meson is measured in NA49 via the invariant mass of its decay products $K^+K^-$ \[4\]. The combinatorial background from random pairs is well described by means of the event-mixing method. The invariant mass distributions and the obtained rapidity spectra for 40, 80 and 158 A·GeV are given in Refs. \[4\]. The extracted total $\phi$ yields normalized to the average number of pions $\pi^\pm = 0.5(\pi^+ + \pi^-)$ are illustrated in the right plot of Fig.\[4\]. This ratio shows the same monotonic rise from AGS to RHIC energies as the $K^-/\pi^-$ ratio.

In summary, the $\Lambda/\pi$ ratio shows a maximum around 30 A·GeV, whereas the $\bar{\Lambda}/\pi$ ratio exhibits a continuous rise. The $\phi/\pi$ ratio also increases monotonically with energy. In the measured energy range the inverse slope parameter slightly increase for $\Lambda$, protons, $\phi$, and deuteron, except for $\pi$ and $K$.

References

[1] M. Gaźdicki et al. these proceedings.

