Energy dependence of $K^0_S$ and hyperon production at CERN SPS

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Abstract. Recent results on $K^0_S$ and hyperon production in Pb-Pb collisions at 40 and 158 $A$ GeV/c beam momentum from the NA57 experiment at CERN SPS are presented. Yields and ratios are compared with those measured by the NA49 experiment, where available. The centrality dependence of the yields and a comparison with the higher collision energy data from RHIC are discussed.

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1. Introduction

The main physics aim of the NA57 experiment [1] at CERN SPS is the study of the onset of the multi-strange baryon and antibaryon enhancements in Pb-Pb collisions with respect to proton-induced reactions. The enhancement effect was first observed by WA97 at 158 $A$ GeV/c beam momentum [2]: NA57 has extended the WA97 measurements over a wider centrality range and to lower beam momentum. The experimental apparatus, described in details elsewhere [3], detects strange and multi-strange hyperons by reconstructing their weak decays into final states containing charged particles only. The centrality trigger selects the most central about 60% of the inelastic cross section for Pb-Pb collisions. The centrality of the collision is controlled through accurate analysis of the charged particle multiplicity sampled at central rapidity by two stations of silicon strip detectors.

2. Results and discussion

The particle selection procedure is based on geometrical and kinematical cuts and allows the extraction of clean signals with negligible background [4]. The collision centrality is expressed as the number of wounded nucleons computed from the multiplicity distribution and the measured trigger cross section via the Glauber model, according to the procedure described in [5].

The double-differential distribution in rapidity $y$ and transverse mass $m_T$ ($d^2N/dm_Tdy$) for each particle type has been fitted, with the corresponding inverse slope parameters

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$(T_{\text{app}})$ extracted as reported in [6]. Yields have then been calculated as the number of particles per event extrapolated to a common phase space window, covering full $p_T$ and one unit of rapidity around midrapidity:

$$Y = \int_m^\infty dm_T \int_{y_{cm}-0.5}^{y_{cm}+0.5} \frac{d^2N}{dm_T dy} \ .$$

In the following of this paper, after a comparison with the results from the NA49 experiment, we show the dependence of the $K^0_S$, $\Lambda$, $\Xi$ and $\Omega$ yields on centrality and energy in Pb-Pb collisions. A comparison with data from Au-Au collisions at RHIC is included. The analysis of the transverse mass spectra and the energy dependence of the hyperon enhancements are discussed in detail in the contribution to this conference by G E Bruno [6].

2.1. Comparison with NA49

We have compared hyperon yields and ratios at both 40 and 158 $A$ GeV/$c$ beam momentum with the available published results from corresponding measurements performed by the NA49 Collaboration [7]. For this comparison we have restricted our data to centrality ranges corresponding to those of NA49; the $K^0_S$ yields for NA49 have been extracted from the published yields for charged kaons.

The NA49 yields are systematically lower than those measured by NA57 by about 30%, both in the 40 and 158 $A$ GeV/$c$ data. Investigations are ongoing to find out the source of this discrepancy. Nevertheless, as shown in Figure 1, the systematics on the absolute yields cancel out when calculating particle ratios.

![Figure 1. Comparison of particle ratios measured by NA57 and NA49 experiments.](image)

2.2. Energy and centrality dependence of the yields

NA57 has measured $K^0_S$ and hyperon yields as a function of centrality both in 40 and 158 $A$ GeV/$c$ Pb-Pb collisions. Results on yields at mid-rapidity in $\sqrt{s_{NN}} = 130$ GeV Au-Au collisions have been published by the STAR Collaboration at RHIC [8]. For comparison, we have restricted our data to the same centrality ranges used in STAR.
Energy dependence of $K^0_S$ and hyperon production at CERN SPS (most central 6%, 5%, 10%, 11% collisions for $K^0_S$, $\Lambda$, $\Xi$ and $\Omega$ respectively). We show then in Figure 2 our yields per unit rapidity at 40 $A$ GeV/$c$ ($\sqrt{s_{NN}} = 8.8$ GeV) and 158 $A$ GeV/$c$ ($\sqrt{s_{NN}} = 17.3$ GeV) together with those from STAR.

![Figure 2. $K^0_S$ and hyperon yields at central rapidity at SPS and RHIC energies.](image)

The $\Lambda$ and $\Xi^-$ yields do not vary much from SPS to RHIC, while a clear energy dependence is seen for all three antihyperons. The antihyperon to hyperon ratios are plotted in Figure 3 as a function of $\sqrt{s_{NN}}$ from SPS to RHIC.

![Figure 3. Comparison of antihyperon to hyperon ratios at SPS and RHIC energies.](image)

The large error bars on the $\Omega^+ / \Omega^-$ ratio are due to the restriction of the NA57 data sample to the STAR $\Omega$ centrality range. The ratios increase with increasing strangeness.
content of the hyperon, both at RHIC and SPS energies. They also increase as a function of the energy, the dependence being weaker for particles with higher strangeness content. This can be understood as due to a baryon density decrease at midrapidity with increasing energy.

The behaviours of the yields with the collision centrality have been also studied. All the yields grow faster than linearly with the number of participants, with a steeper centrality dependence for the lower energy data. At the lower energy, the statistics does not allow a firm conclusion for $\Xi^+$ and $\Omega$. The analysis of the p-Be data at 40 GeV/c has allowed calculations of strangeness enhancements also at the lower energy: the results are reported at this conference in [6].

3. Conclusions

Results on $K^0_S$ and hyperon production measured by the NA57 experiment in 40 and 158 A GeV/c Pb-Pb collisions have been reported. The measured yields at midrapidity have been compared with the results of measurements carried out by the NA49 Collaboration: we find a 30% systematic discrepancy on the absolute yields, while no discrepancy is observed when calculating particle ratios.

The energy dependence study, where yields at SPS energies are compared with those at RHIC, shows that $\Lambda$ and $\Xi^-$ yields per unit rapidity stay roughly constant while a clear increase with energy is seen for all three antihyperons. The antihyperon to hyperon ratios increase with energy, with a stronger dependence for particles with lower strangeness content. Such a pattern is consistent with a decrease of the baryon density in the central region with increasing energy. We also observe a steeper centrality dependence of the yields (and then of the enhancements) at lower energy.

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