Hyperon production in Pb+Pb collisions at the CERN-SPS

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Abstract
New results on the production of Ξ and Ω hyperons in Pb+Pb interactions at 40 A GeV and Λ at 30 A GeV are presented. Transverse mass spectra as well as rapidity spectra of these hyperons are shown and compared to previously measured data at different beam energies. The energy dependence of hyperon production (4π yields) is discussed. Additionally, the centrality dependence of Ξ^- production at 40 A GeV is presented.

(Some figures in this article are in colour only in the electronic version)

1. Introduction

Measurements of strange particles provide information on the properties of strongly interacting matter at early stages of heavy ion collisions. On the assumption that a deconfinement phase transition occurs in heavy ion collisions, we have to look for qualitative changes (onset phenomena) when varying external parameters such as system size and energy density. Therefore, we study Λ, Ξ and Ω production as a function of beam energy and Ξ^- production dependent on the collision centrality. This contribution reports on the first results of the Λ production at 30 A GeV and Ξ and Ω production at 40 A GeV.

2. The NA49 experiment

The NA49 experiment [1] is a large acceptance hadron spectrometer which consists of four TPCs. The two vertex TPCs are located in a strong magnetic field. They allow the measurement of charge and momentum of the detected particles. The two main TPCs are outside the magnetic field. They are used for particle identification via the dE/dx measurement. A veto colorimeter
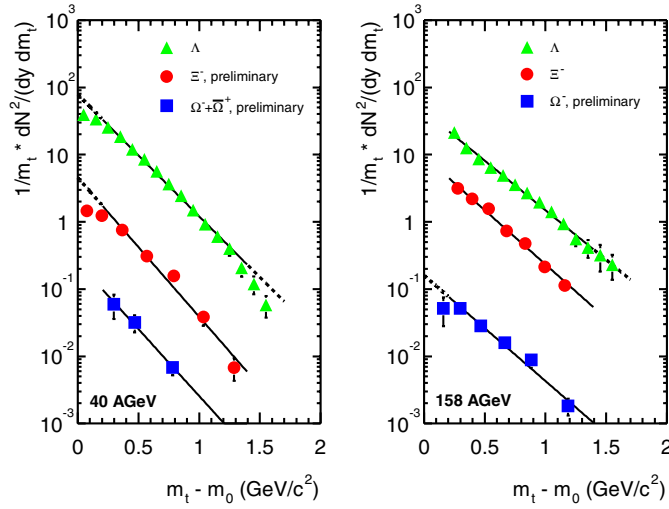
Figure 1. Transverse mass spectra of Λ (triangles), Ξ (circles), Ω (squares) produced in central Pb+Pb collisions at 40 (left) and 158 A GeV (right). The Λ spectra are uncorrected for feeddown from Ξ and Ω decays.

which is placed downstream of the TPCs measures the energy of spectator nucleons from which the collision centrality can be inferred.

3. Transverse mass spectra and inverse slope parameters

In figure 1 results on m_T-spectra of hyperons at 40 and 158 A GeV at mid-rapidity measured in central Pb+Pb collisions by NA49 are summarized. Because of the good signal to background ratio at 40 A GeV, Λ and Ξ cover almost the full m_T-region. The Ξ at 158 A GeV have already been published [2], while the Λ-spectra at both energies are submitted for publication [3]. All other presented results are still preliminary. At low and high m_T the spectra deviate from an exponential shape. Because of this all spectra are fitted with a simple exponential function only in a limited $m_T–m_0$ range (0.2–1.4 GeV/c^2). From these fits the following inverse slope parameters at 40 A GeV are derived: $T_{\Xi^-} = (210 \pm 11)$ MeV, $T_{\Omega^-+\bar{\Omega}^+} = (218 \pm 39)$ MeV. At 40 A GeV the signals of Ω^- and $\bar{\Omega}^+$ hyperons are summed because of low statistics.

4. Rapidity spectra and total yields

The NA49 detector is able to measure particles in a broad rapidity range. In figure 2 the rapidity distributions of Λ, Ξ and Ω produced in central Pb+Pb collisions at several beam energies are shown. The Λ rapidity spectra at 30 A GeV, the Ξ^- rapidity spectra at 40 A GeV and the Ω-spectra at 40 and 158 A GeV are parametrized by Gaussians as indicated by the full lines. The Λ-spectrum at 80 and the Ξ-spectrum at 158 A GeV are parametrized by the sum of two Gaussians displaced symmetrically with respect to mid-rapidity. A clear evolution of the shape of the Λ-spectra is visible. For Ξ^- and Ω we observe an increase of the width of the rapidity distributions with beam energy, but no indication for a change of the shape. The measured rapidity spectra have been integrated to obtain the total multiplicities in the full phase space; for numerical values see table 1.
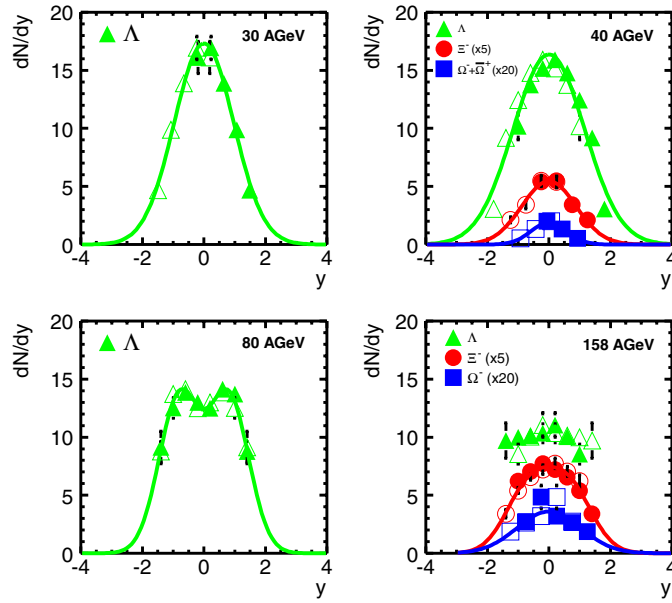
Figure 2. Rapidity spectra of Λ (triangles), Ξ^- (circles) and Ω (squares) produced in central Pb+Pb collisions at 30, 40, 80 and 158 A GeV. Filled symbols are measured, and open ones are reflected at mid-rapidity. For clarity the Ξ-spectra are scaled by a factor 5 and the Ω-spectra by a factor 20. The Λ-spectra are uncorrected for feeddown from Ξ and Ω. All spectra are preliminary except Ξ^- at 158 A GeV.

Table 1. Total yields of the hyperons produced in central Pb+Pb collisions at several beam energies. The fraction of the selected cross section is given in the first row. The Λ yields are uncorrected for feeddown from Ξ and Ω. The first given error is statistical and the second one is systematic.

Beam energy	30 A GeV	40 A GeV	80 A GeV	158 A GeV
$\sqrt{s}$	7.62 GeV	8.73 GeV	12.30 GeV	17.30 GeV
$\sigma^{\mathrm{cent}}/\sigma^{\mathrm{inel}}$	7.2%	7.2%	7.2%	10% (Ω: 20%)
$\langle\Lambda\rangle$	$41.9 \pm 2.1 \pm 4.0$	$45.6 \pm 1.9 \pm 3.4$	$47.4 \pm 2.8 \pm 3.5$	$44.1 \pm 3.2 \pm 5.0$
$\langle\Xi\rangle$	–	$2.41 \pm 0.15 \pm 0.24$	–	$4.12 \pm 0.20 \pm 0.62$
$\langle\Omega^- + \bar{\Omega}^+\rangle$	–	$0.20 \pm 0.03 \pm 0.04$	–	0.62 ± 0.07
$\langle\Omega^-\rangle$	–	–	–	0.47 ± 0.07

5. Energy dependence of hyperon production

The total multiplicities of Λ, Ξ and Ω are plotted as a function of the centre of mass energy in figure 3. All yields are divided by the total multiplicities of the negatively charged pions. The energy dependence of the Λ hyperons shows a clear maximum at about 30 A GeV ($\sqrt{s} = 7.62$ GeV). The $\langle\Xi^-\rangle/\langle\pi^-\rangle$ ratio shows a weak maximum at 40 A GeV ($\sqrt{s} = 8.73$ GeV). The non-monotonic behaviour is not seen for the $\langle\Omega^- + \bar{\Omega}^+\rangle/\langle\pi^-\rangle$ ratio. The dashed lines show a prediction of a grand canonical hadron-gas model, which includes the variations of the baryochemical potential and the temperature with the beam energy [4]. The model describes the basic features of our data within 30%.
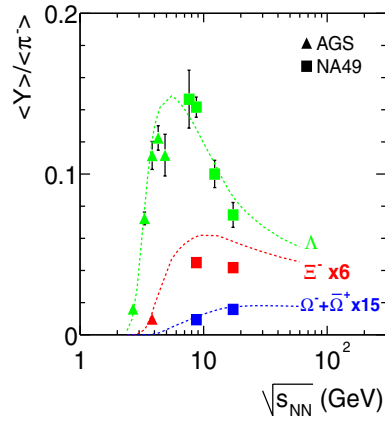
Figure 3. Energy dependence of the hyperon to π^- ratio (measured in 4π) compared to a prediction of the hadron-gas model. For clarity the Ξ curve is scaled by a factor 6 and the Ω curve by a factor 15.
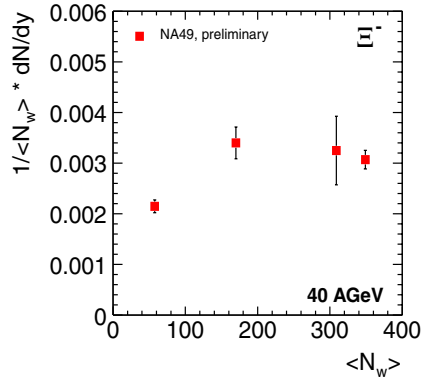

Figure 4. Centrality dependence of Ξ^- production in Pb+Pb collisions at 40 A GeV (mid-rapidity) as measured by NA49. All values are normalized by the mean number of wounded nucleons N_W.

6. Centrality dependence of Ξ^- production

In figure 4 the centrality dependence of Ξ^- production at 40 A GeV at mid-rapidity is shown. The yields are normalized by the mean number of wounded nucleons [5]. The Ξ^- production increases from peripheral to midcentral collisions and this behaviour is followed by a saturation towards central reactions.

References

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