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Hyperon production in lead-lead interactions at 40 and 160 A GeV/c

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Abstract. The NA57 experiment has measured strange baryon and antibaryon production in Pb-Pb collisions at 40 A GeV/c and 160 A GeV/c beam momenta. This presentation covers strangeness enhancement and transverse spectra from the 160 A GeV/c data, and energy dependence of the particle yields. Enhancement factors increase with increasing strangeness content of the particle, when production yields from Pb-Pb collisions are compared with those observed in p-Be and p-Pb interactions. The transverse mass spectra have been analysed both with exponential fits and using a transverse flow model.

1 Introduction

The NA57 experiment has been designed to study the production of strange baryons and antibaryons in heavy ion collisions. The experiment has extended the WA97[1] measurements to a wider centrality range and to lower beam momentum. The NA57 results on hyperon production at 160 A GeV/c confirm the pattern observed by WA97, where the enhancement factor increases with increasing

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strangeness content of the particle. The largest enhancement is observed for Ω hyperons, reaching a factor of 20.

The experimental setup of NA57 is briefly outlined. Analysis of the transverse mass spectra is discussed. Enhancements for the complete NA57 centrality range are presented for 160 A GeV/c data. Yields obtained from 40 A GeV data are presented and compared to 160 GeV/c data and to measurements from RHIC.

2 The NA57 experiment

The layout of the NA57 experiment has been described in detail elsewhere[2]. A telescope of compactly packed silicon pixel detectors is used as main tracking device. Additional detectors are used to improve momentum resolution for high momentum tracks.

Scintillator counters are used to provide a fast signal for multiplicity triggering. A more precise centrality measurement is provided by two stations of silicon strip detectors. The detectors are located in the 1.4 T field of the Goliath magnet. The triggered fraction of the total inelastic cross section is about 60 %.

Hyperons are identified by their decay patterns. All decays are required to take place in the decay region, located between a fixed distance from the target and the first plane of the telescope. The selection procedure allows for extraction of hyperon signals with negligible background[3].

The centrality is expressed as number of wounded nucleons computed from the measured trigger cross sections using a Glauber model. The method of centrality determination is described in detail in[5].

3 Transverse mass spectra

The double-differential (y, m_{T}) cross sections have been fitted using the expression

$$\frac{\mathrm{d}^2N}{\mathrm{d}m_{\mathrm{T}}\mathrm{d}y} = f(y)m_{\mathrm{T}}\mathrm{exp}\left(-\frac{m_{\mathrm{T}}}{T}\right) \tag{1}$$

where $m_{\mathrm{T}} = \sqrt{m^2+p_{\mathrm{T}}^2}$ is the transverse mass, and the rapidity distribution $f(y)$ is assumed to be constant over the acceptance window (one unit of rapidity around the central rapidity of the collision). Slopes[4] obtained from fits using this expression are used to determine the yields presented in section 4.

The transverse mass spectra have also been fitted using a collective flow model originating from ref. [6]. The data are compatible with a description using two parameters only (temperature T and average transverse flow $\beta_\perp$), as shown in figure 1. However, the weight of the multistrange particles in such a fit is rather small.

The numbers quoted in the figure are obtained using the whole NA57 centrality range. The centrality dependence of the two parameters show opposite trends, the temperature is decreasing and the average flow velocity is increasing with increasing centrality. The values for the most central class (IV) are T = 131 ± 10 MeV and β_{T} = 0.47 ± 0.02. These numbers agree within errors with NA49 results obtained with a similar approach[8].

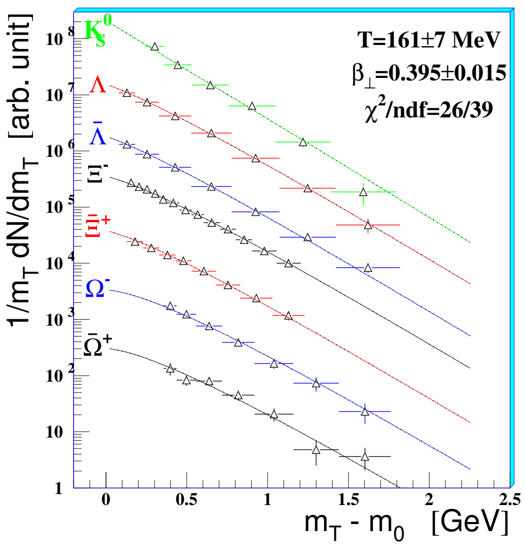

Fig. 1. Transverse mass spectra fitted with collective flow model. The quoted values are valid for the full NA57 centrality sample.

The transverse mass spectrum analysis is described in detail in ref. [9]

4 Strangeness enhancement

Yields are calculated by integrating the formula described in section 3

$$Y = \int_m^\infty \mathrm{d}m_T \int_{y_{cm}-0.5}^{y_{cm}+0.5} \frac{\mathrm{d}^2N}{\mathrm{d}m_T\mathrm{d}y}\mathrm{d}y \tag{2}$$

for each particle species. Due to low statistics, a common slope was used for extrapolation of the Ω^- and $\overline{\Omega}^+$ spectra.

The enhancement factor is defined as

$$E = \left(\frac{Y}{< N_{\mathrm{wound}} >}\right)_{\mathrm{Pb-Pb}} / \left(\frac{Y}{< N_{\mathrm{wound}} >}\right)_{\mathrm{p-Be}} \tag{3}$$

The strangeness enhancement factors, plotted as function of collision centrality, are shown in figure 2. The p-Be and p-Pb values are taken from WA97[10]. The NA57 results confirm the picture emerging from WA97, where the enhancement increases with increasing strangeness content of the particle in lead-lead interactions, opposite to what would be expected from hadronic thermalization models.

A significant dependence on centrality is observed for all hyperons except $\overline{\Lambda}$. A saturation of the enhancements is possible in the two or three most central classes (the about 10% most central collisions).

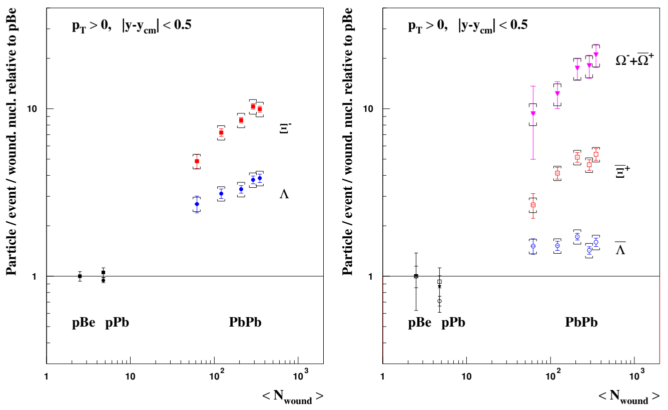

Fig. 2. Hyperon enhancements E as function of collision centrality (number of wounded nucleons)

5 Energy dependence of particle yields

Figure 3 shows hyperon yields from NA57 measured at 40 and 160 A GeV/c compared to RHIC data from STAR[11–13]. The centrality selection is compatible with the ranges published by STAR, selecting the 5%, 10% and 11% most central collsions for Λ, Ξ and Ω respectively. By this centrality selection only a sub-sample of the total NA57 hyperon sample is included. Both at 40 A GeV/c and at 160 A GeV/c the combined Ω^- and $\overline{\Omega}^+$ data are used to obtain the inverse slope used for extrapolation.

The observed pattern is clearly different for hyperons and antihyperons. The Λ and Ξ^- yields are rather constant over the energy range covered. The antihyperon yields increase with energy, approaching the same level as the hyperon yields at RHIC energies.

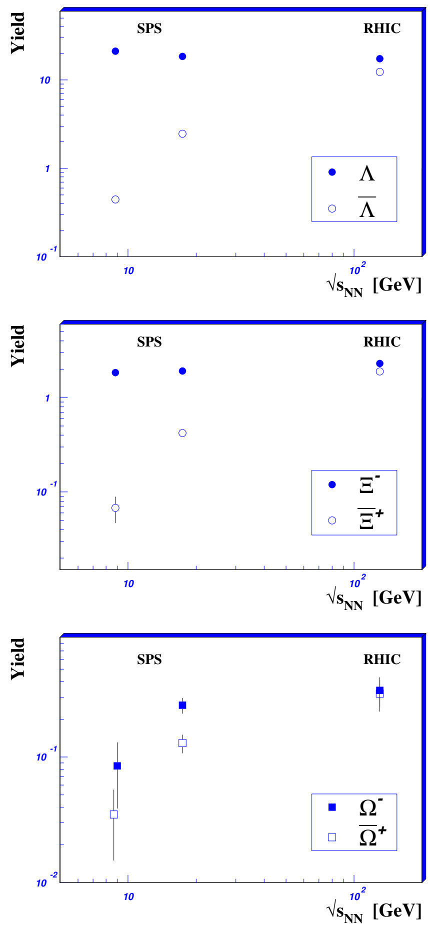

Fig. 3. Energy dependence of hyperon yields in central heavy ion collisions. The NA57 data have been restricted to the 11% most central collisions in order to compare with STAR data.

6 Conclusions and outlook

NA57 results on hyperon production have been presented. Strangeness enhancements are presented for 160 A GeV/c data, showing increasing enhancements with increasing strangeness content of the hyperon. The energy dependence of hyperon and antihyperon yields show a different behaviour, with strong energy dependence of antihyperon production. The results of a fit of the transverse mass spectra to a blast wave model have been presented.

Analysis of proton-beryllium data at 40 GeV/c is ongoing. Strangeness enhancement factors at this energy will become available when this analysis is completed.

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