MULTI-STRANGE BARYON PRODUCTION IN Pb–Pb AND p–Pb COLLISIONS

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New data from the CERN WA97 experiment on Ξ and Ω production in p–Pb and Pb–Pb collisions at 158 GeV/c per nucleon are presented. They confirm the recent indication [1] that the Ω/Ξ ratio is significantly higher in Pb–Pb compared to p–Pb reactions.

1 Introduction

The study of the strange particle production in high-energy nucleus-nucleus collisions provides important information on the behaviour of excited nuclear matter. The enhanced relative yield of strange and, particularly, multi-strange particles and anti-particles in nucleus-nucleus with respect to hadronic reactions has been suggested as a signature of the phase transition to a quark-gluon plasma (QGP) state [2,3].

In the QGP scenario such an enhancement could be created in a time interval comparable with the interaction time of the high-energy heavy-ion collision (a few fm/c). On the contrary, in a purely hadronic scenario the establishment of a similar system requires much longer time. It can be expected [4] that the enhancement should be more pronounced for multi-strange than for singly-strange particles because of the high density of $s\bar{s}$ - pairs in the plasma and, on the other hand, the suppression of strange particle production in hadronic processes which increases with the growing strangeness content.

Such a behaviour has been observed for particles with strangeness $|s| = 1$ and 2 in sulphur initiated reactions by the WA85 and WA94 experiments [5,6]. It is therefore of considerable interest to extend this study to the really heavy-ion (Pb–Pb) collisions and to the Ω hyperons with $|s| = 3$.

The WA97 experiment performed at the CERN SPS aims to cope with this task exploiting its capability to perform precise measurements of particles in a high multiplicity environment and to reconstruct reliably the cascade decays of Ξ and Ω hyperons.

2 Experimental set-up

The experimental set-up, shown schematically in fig. 1, is described in detail in ref. [7].

Multiplicity detectors located near the lead target provide a centrality trigger selecting about 30% of the Pb–Pb cross section. In addition, they provide detailed information allowing off-line study of multiplicity dependences.

The core of the WA97 set-up is a silicon telescope consisting of silicon microstrip planes with a 50 μm pitch and of the novel pixel detectors [8] with a pixel size of 75×500 μm^2. The telescope, providing $\simeq 0.5$ M detecting elements

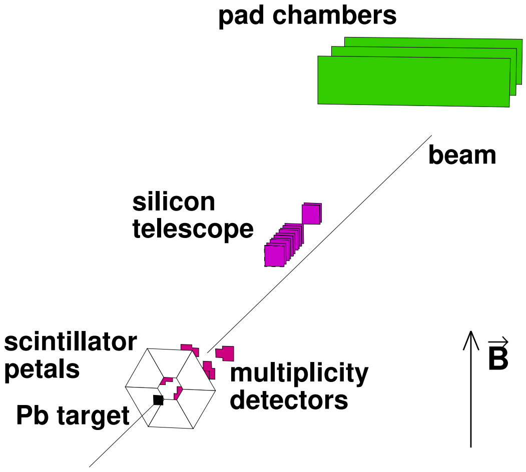

Figure 1: WA97 set-up in the Omega magnet.

for precise coordinate measurements, is placed inside the 1.8 T magnetic field of the CERN Omega spectrometer.

The identification of tracks is done in the compact part of the telescope where silicon planes with surface of 5×5 cm^2 are closely packed over a distance of 30 cm. The momentum resolution of fast tracks is improved by use of lever arm detectors consisting of additional pixel and microstrip planes and of three MWPC's with a pad cathode readout.

Additional information for the selection of central collisions is provided by the zero degree calorimeter (not shown in the figure) placed about 26 m from the target.

The geometrical acceptance of the apparatus covers the region of central rapidity ($2.5 < y_{\mathrm{L}} < 3.5$) and medium transverse momentum ($p_\perp > 0.5$ GeV/c) and is the same for particles and antiparticles.

3 Data samples and selection criteria

The results presented here are based on analysis of three data samples taken in different experimental conditions :

a) 120×10^6 p–Pb events taken in 1995 run with the telescope placed at the distance $d = 90$ cm from the target and under the trigger requirement to have at least two charged particles in the telescope ;

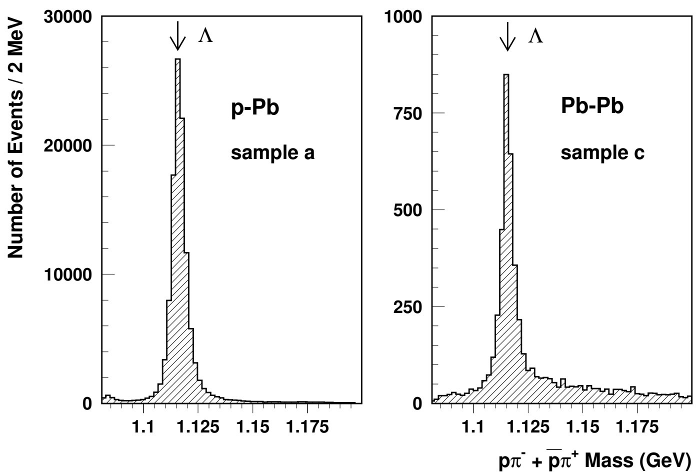

Figure 2: Uncorrected $\Lambda+\overline{\Lambda}$ signal in p–Pb and Pb–Pb data.

b) 9×10^6 Pb–Pb events taken in 1994 run at $d = 90$ cm with an average track multiplicity in the telescope $n_t \simeq 6$;

c) 3×10^6 Pb–Pb events taken in 1995 run at $d = 60$ cm and with $n_t \simeq 20$[a].

The Ω^- and Ξ^- hyperons (and the corresponding antihyperons) are identified by reconstructing their two-step decays containing only charged particles in the final state, i.e.

$$\Xi^- \rightarrow \Lambda\pi^- \ , \ \Omega^- \rightarrow \Lambda K^- \ \ (\Lambda \rightarrow p\pi^-).$$

All decays are required to fall within a decay region, starting at 40 cm from the target (at 20 cm for the sample c) and ending just before the first sensitive plane of the silicon telescope. All decay tracks are required to pass through all the planes of the compact part of the telescope. At both vertices of the Ω or Ξ cascade decays a distance of closest approach between the trajectories of decay products less than 0.5 mm is required. The standard set of cuts, analogous to those described in ref. [6], has been applied to eliminate the background. For the Ω (Λ) candidates the unambiguity with Ξ (K^0) was required.

As an illustration of the quality of the data obtained by the described selection procedure, the reconstructed $\Lambda+\overline{\Lambda}$ signals are presented in fig. 2.

[a]this sample represents a fraction of the total statistics of about 100 M of triggers. Analysis of the remaining data is in progress.

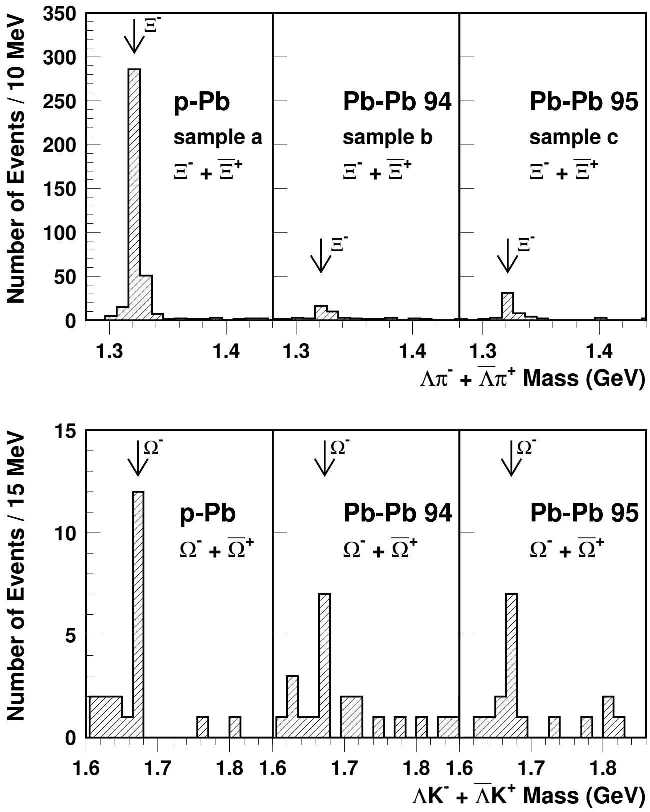

Figure 3: Uncorrected Ξ and Ω signals.

4 Results

Fig. 3 shows the uncorrected $\Xi^- + \overline{\Xi}^+$ and $\Omega^- + \overline{\Omega}^+$ signals for data samples a), b) and c).

At the present stage of analysis, the relative normalization between these samples has not yet been determined. Therefore we can only compare the observed Ω/Ξ ratios.

The geometrical acceptance was the same for samples a) and b), but different for the 1995 Pb–Pb data (sample c). The integral acceptance for the Ω/Ξ ratio is however only by $\simeq$ 10% higher for the sample c). We assume the reconstruction efficiencies for Ξs and Ωs to be the same (for a given data sample) and therefore to cancel in the Ω/Ξ ratio. This assumption is based on the fact that both particles are identified by reconstructing three tracks in the telescope.

Comparison of the observed Ω/Ξ ratios shows that two different Pb–Pb samples are giving similar, statistically consistent results. There is, however, a striking difference between Ω/Ξ ratios in the p–Pb and the Pb–Pb samples. If the Ω/Ξ production ratio were to be the same in p–Pb as in Pb–Pb collisions, one would expect an Ω signal in the p–Pb sample about five times stronger than the one shown in fig. 3.

5 Conclusions

The new data on the Ω/Ξ ratios in p–Pb and Pb–Pb collisions at 158 GeV/c per nucleon are presented. They are based on statistics doubled with respect to that quoted in ref. [1], for both p–Pb and Pb–Pb samples.

The presented results are consistent with the previous ones thus strengthening the conclusion that the Ω production is significantly enhanced with respect to Ξ production in Pb–Pb compared to p–Pb reactions.

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