PRODUCTION OF MULTI-STRANGE BARYONS IN Pb-Pb COLLISIONS AT THE SPS ENERGY

Presented by N. CARRER for the WA97 collaboration:

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Abstract

The first results on the fully corrected ratios of Ω^-, $\overline{\Omega}^+$, $\Xi^-$and $\overline{\Xi}^+$detected by the WA97 experiment in Pb-Pb collisions are presented.

1 Introduction

The analysis of strange particles yields has been proposed as a useful tool to study the properties of the hot and dense hadronic fireball formed in nuclear collisions. Enhancement of the production of strange particles in nuclear collisions with respect to hadronic collisions has been proposed as a signature of the onset of a quark-gluon plasma (QGP) phase. In particular multi–strange baryons and anti–baryons are interesting since they are especially difficult to be produced in purely hadronic interactions [1, 2].

The WA85 and WA94 experiments reported an enhanced Ξ ($|s| = 2$) over Λ ($|s| = 1$) production in S–W and S–S interactions with respect to pp and pA collisions (fig. 1).

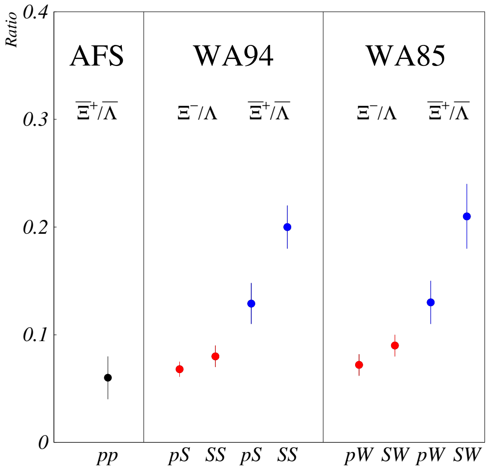

Figure 1: *Compilation of AFS, WA94 and WA85 data on Ξ/Λ ratios.*

The use of lead beams at the CERN SPS allows us to study the evolution of this enhancement for really heavy nuclei.

2 Experimental setup

The WA97 experiment was designed to study the production of strange and multi-strange baryons in Pb–Pb and p–Pb collisions. The setup, shown in fig. 2, was described in detail in ref. [4]. It consists mainly of a spectrometer placed in the 1.8 Tesla magnetic field generated by the super-conducting OMEGA magnet.

The centrality of the collision is obtained through the charged particle multiplicity measured by an array of silicon micro-strips placed in front of the target and covering the pseudo-rapidity interval $2.1 < \eta < 4$. The trigger accepts 30% of the total interaction cross section.

The core of the detector is a tracking device ("pixel tracking chamber" or PTC) consisting of micro-strips and silicon pixel planes [5]. The pixel planes have an area of $5 \times 5\,\mathrm{cm}^2$ and the sizes of each pixel are $75 \times 500\,\mu\mathrm{m}^2$. The pixels give 2–dimensional informations on the track impact position which allow to cope very efficiently with the high track multiplicity of central Pb–Pb events. The total length of the PTC is $\simeq$ 60 cm and in the Pb–Pb runs the target was placed at a distance of 60 cm from the first plane. The track finding is performed on the first 30 cm of the PTC where most of the planes are placed. Two additional planes of pixels and micro-strips are placed at 60 cm and a set of multi-wire proportional chambers with pad cathode readout are placed further away to improve the momentum resolution of fast tracks.

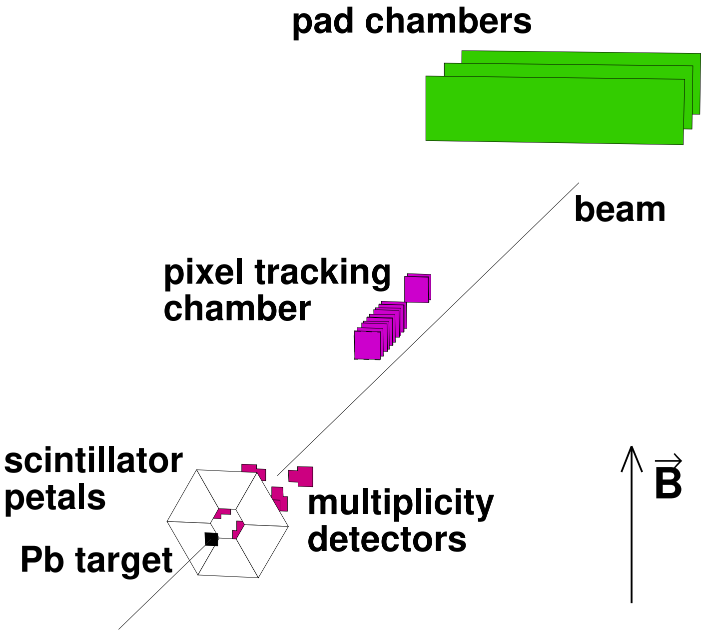

Figure 2: *WA97 detector set-up placed in the Omega magnet.*

3 Data sample and signal selection

The data sample analysed consists of about $42 \cdot 10^6$ triggers of Pb–Pb collisions and $120 \cdot 10^6$ triggers of p–Pb collisions.

Ξ's and Ω's are identified by their decay in the charged final state:

$$\begin{array}{l} \Xi^- \rightarrow \Lambda + \pi^- \\ \qquad\ \ \downarrow \\ \qquad\ \ \mathrm{p} + \pi^- \end{array} \qquad \text{(and charge conjugate decay)}$$

$$\begin{array}{l} \Omega^- \rightarrow \Lambda + \mathrm{K}^- \\ \qquad\ \ \downarrow \\ \qquad\ \ \mathrm{p} + \pi^- \end{array} \qquad \text{(and charge conjugate decay).}$$

The selection criteria used to extract the signals are summarised below:

- all decay tracks are required to pass through each plane of the compact part of the PTC;
- all decay vertices are required to fall inside a decay region located before the first plane of the PTC;
- the reconstructed Λ vertex must follow the $\Xi(\Omega)$ vertex;
- the distance between the extrapolated tracks at the decay vertex is required to be less than 0.5 mm;
- a cut on the impact parameters is applied to require that the Ξ's and Ω's come from the

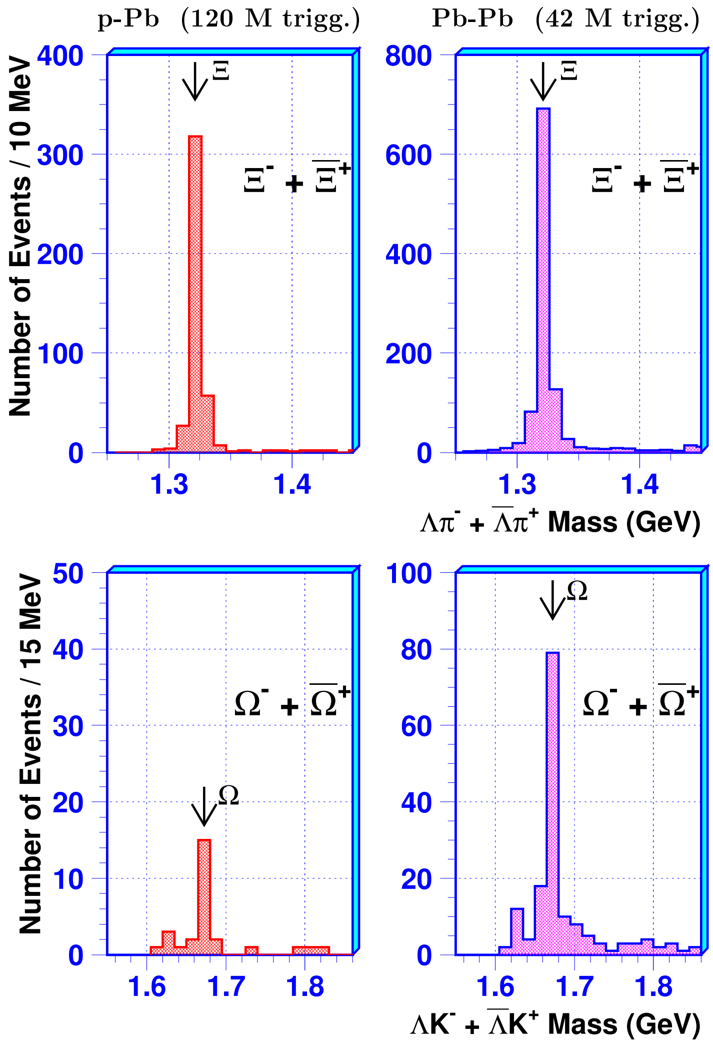

Figure 3: Ξ *and* Ω *signals in p–Pb and Pb–Pb collisions.*

primary vertex and that the decay products do not come from it[1];

- Ω's are required to be kinematically unambiguous with Ξ's.

The analysis shows a clear signal of Ω's and Ξ's both in p–Pb and in Pb–Pb reactions, as can be seen in figure 3.

The relative normalisation between the two samples still has to be determined, however the comparison between the uncorrected proton and lead data suggests that there is an enhancement of Ω ($|s| = 3$) with respect to Ξ ($|s| = 2$) in lead induced reactions by a factor of about 3.

In the p–Pb data taking period the geometrical arrangement was different since the distance between the target and the PTC was 90 cm [3]. However the integrated acceptance for the Ω/Ξ ratio was only higher by $\simeq$ 10% for the Pb–Pb sample. As will be noted in section 5, the efficiency for Ξ's and Ω's in the Pb–Pb sample is the same. We expect that this will remain true also for the p–Pb data where the track multiplicity is lower.

[1] The high multiplicity of tracks in the PTC ($\simeq$ 20 tracks per event) allows a precise determination of the primary vertex position event by event.

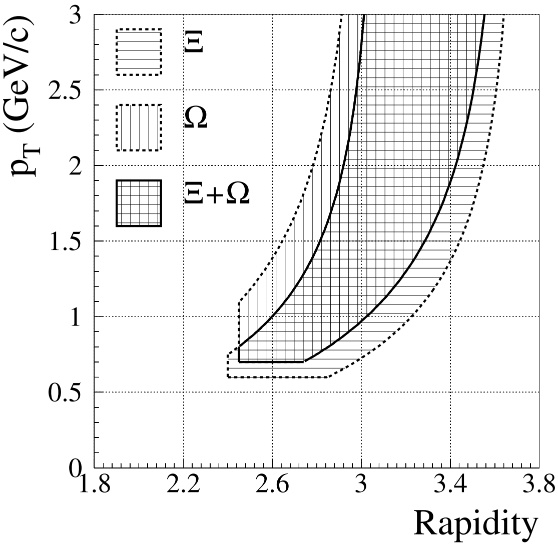

Figure 4: *Acceptance windows for* Ξ *and* Ω.

4 Data sample and efficiency calculation

The Pb–Pb data were corrected for acceptance, detector and reconstruction efficiency by means of a Monte Carlo simulation based on Geant. The correction of p–Pb data in under way.

For each Ξ and Ω in the real data sample a total efficiency weight was evaluated. The efficiency calculation was performed by generating events with the measured p_T, rapidity and the event-by-event determination of the primary vertex. This was allowed by the high track multiplicity in the PTC. A detector efficiency was measured for each chip of the pixel planes[2] and taken into account in the reconstruction efficiency calculation. The simulation of background tracks and electronic noise was performed without assumption of any model, but embedding the digitising of the generated Ξ or Ω tracks in a background event (i.e. a real event accepted by the trigger) which has a similar hit multiplicity in the PTC.

Simulated events were then processed in the same way as real ones for pattern recognition as well as track fitting and signal selection. Each real event was then weighted by the inverse of its efficiency to give the corrected yields.

The detector acceptance windows for Ξ's and Ω's are shown in figure 4. They extend to about one unit of rapidity around mid-rapidity and the minimum transverse momentum is $0.6\,\mathrm{GeV}/c$ for Ξ's and $0.7\,\mathrm{GeV}/c$ for Ω's.

Mixed ratios were evaluated in the overlapping window of the two acceptances (see fig. 4).

5 Results

The ratios of Ξ's and Ω's yields are given in table 1. Both acceptance and efficiency are similar for Ξ's and Ω's. As a consequence the ratios do not change very much after correction. All ratios are corrected for the branching fractions of the unseen decay modes.

The data sample analysed corresponds to about one fourth of the statistics collected by the WA97 experiment in the Pb–Pb runs, so we expect to reduce the errors on the ratios by a factor of about 2.

[2]A plane of pixels consists of 72 chips.

Table 1: *Ratios of multi-strange baryons measured by the WA97 experiment.*

Uncorrected		
$\frac{\overline{\Xi}^+}{\Xi^-} = 0.26 \pm 0.02$	$\frac{\Omega^-}{\Xi^-} = 0.16 \pm 0.02$	$\frac{\Omega^- + \overline{\Omega}^+}{\Xi^- + \overline{\Xi}^+} = 0.18 \pm 0.02$
$\frac{\overline{\Omega}^+}{\Omega^-} = 0.39 \pm 0.08$	$\frac{\overline{\Omega}^+}{\overline{\Xi}^+} = 0.24 \pm 0.05$	
Corrected in all acc. window		
$\frac{\overline{\Xi}^+}{\Xi^-} = 0.25 \pm 0.05$	$\frac{\Omega^-}{\Xi^-} = 0.13 \pm 0.02$	$\frac{\Omega^- + \overline{\Omega}^+}{\Xi^- + \overline{\Xi}^+} = 0.16 \pm 0.02$
$\frac{\overline{\Omega}^+}{\Omega^-} = 0.54 \pm 0.15$	$\frac{\overline{\Omega}^+}{\overline{\Xi}^+} = 0.29 \pm 0.08$	
Corrected in overlap window		
$\frac{\overline{\Xi}^+}{\Xi^-} = 0.27 \pm 0.05$	$\frac{\Omega^-}{\Xi^-} = 0.19 \pm 0.04$	$\frac{\Omega^- + \overline{\Omega}^+}{\Xi^- + \overline{\Xi}^+} = 0.21 \pm 0.03$
$\frac{\overline{\Omega}^+}{\Omega^-} = 0.42 \pm 0.12$	$\frac{\overline{\Omega}^+}{\overline{\Xi}^+} = 0.30 \pm 0.09$	

References

[1] J. Rafelski and B. Müller, *Phys. Rev. Lett.* **48** (1982) 1066;
J. Rafelski and B. Müller, *Phys. Rev. Lett.* **56** (1986) 2334.

[2] P. Koch, B. Müller and J. Rafelski, *Phys. Rep.* **142** (1986) 167.

[3] L. Šándor for the WA97 coll., Proceedings of the Hirschegg conference '97.

[4] G. Alexeev et al, *Nucl. Phys.* A **590** (1995) 139c.

[5] E.H.M. Heijne et al., *Nucl. Instrum. Methods* A **349** (1994) 138;
F. Antinori et al., *Nucl. Instrum. Methods* A **360** (1995) 91.