Results on 40 A GeV/c Pb-Pb collisions from the NA57 experiment

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The NA57 experiment has been designed to study the onset of the strange baryon and anti-baryon enhancements in Pb-Pb with respect to p-Be collisions, first observed by WA97 at 160 A GeV/c. NA57 has extended the WA97 measurements to investigate the evolution of strangeness enhancement over a wider centrality range and as a function of the beam energy. Results on hyperon production in central Pb-Pb collisions at 40 A GeV/c are presented and compared with those obtained at higher energy, in the same centrality range.

1. THE NA57 EXPERIMENT

The WA97 experiment has observed an increase in the abundance of strange baryons and anti-baryons amongst final state particles, when going from p-Be to central Pb-Pb collisions [1] at 160 A GeV/c. The effect, confirmed by NA57 [2], increases with the strangeness content of the particles: this feature has been predicted [3] to be a consequence of the phase transition to a Quark Gluon Plasma. NA57 has taken data also at the lower beam energy of 40 A GeV/c, both for Pb-Pb and p-Be collisions. The aim was to study the evolution of the strangeness enhancement observed at the top SPS energy [4]: significantly lower enhancements for the 40 A GeV/c data would suggest the onset of the deconfinement to be in between the two interaction energies. In the following absolute yields and inverse slopes of the transverse mass distributions for the Pb-Pb data will be presented. The analysis of proton beam data has yet to be completed.
The NA57 apparatus [4,5] has been designed to detect strange and multi-strange hyperons by reconstructing their weak decays into final states containing only charged particles. Tracks are measured in the silicon telescope, an array of pixel detector planes with 5 × 5 cm^2 cross section, having a total length of 30 cm. The acceptance coverage corresponds to about one unit of rapidity at central rapidity and medium transverse momentum. The centrality trigger, based on a scintillator petal system placed 10 cm downstream of the target, selects the most central 60% of the inelastic cross section for Pb-Pb collisions. The centrality of the collision is determined from the charged particle multiplicity sampled at central rapidity by two silicon strip detector stations (MSD).

2. HYPERON SIGNALS AND CENTRALITY RANGE

Fig.1 shows the hyperon signals reconstructed for the full Pb-Pb sample at 40 A GeV/c: the shadowed regions correspond to the mass cut applied to define the particle samples.

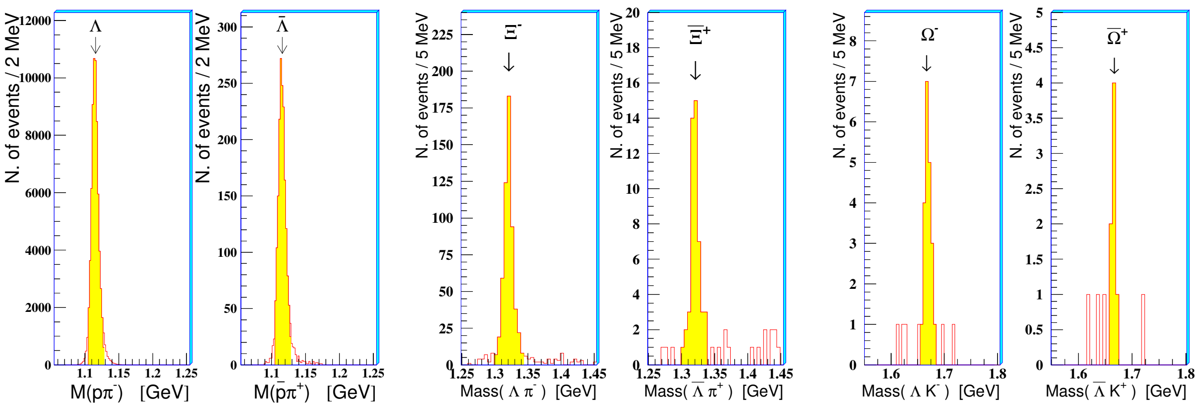

Figure 1. Reconstructed Λ, $\overline{\Lambda}$, Ξ^-, $\overline{\Xi}^+$, Ω^- and $\overline{\Omega}^+$ signals in Pb-Pb at 40 A GeV/c.

We measure the following decay channels: $\Lambda \rightarrow \pi^- p$, $\Xi^- \rightarrow \Lambda\pi^-$ (with $\Lambda \rightarrow \pi^- p$), $\Omega^- \rightarrow \Lambda K^-$ (with $\Lambda \rightarrow \pi^- p$) and the corresponding ones for anti-particles. The study of the collision centrality is based on the charged particle multiplicity sampled by the MSD in the pseudorapidity range $1.9 < \eta < 3.6$, following the same analysis procedure used for the 160 A GeV/c data and described in [6]. The results presented here have been obtained on a sample containing the most central 25% of the Pb-Pb inelastic cross section, with an average number of wounded nucleons $< N_{wound} > = 262 \pm 17$. Such a sample corresponds to the three most central bins of the 160 A GeV/c data analysis [7]. For each selected particle a weight is calculated to take into account geometrical acceptance and efficiency losses [8]. This procedure is still being completed for the Λ sample, while the Ξ and Ω signals have been completely corrected.

3. RESULTS

The transverse mass (m_T) distributions for the Ξ and Ω samples have been described by a maximum likelihood fit according to the following parametrization:

$$\frac{d^2N}{dm_T dy} = A\, m_T \exp\left(-\frac{m_T}{T}\right). \tag{1}$$

The values of the inverse slope parameters T extracted by the fit procedure and the corresponding statistical errors are the following:

Ξ^-: 228 ± 13 MeV $\quad \overline{\Xi}^+$: 280 ± 63 MeV $\quad \Omega^- + \overline{\Omega}^+$: 326 ± 66 MeV.

The Ω^- and $\overline{\Omega}^+$ samples have been merged together due to the low statistics. The inverse slope parameters of the Ξ^- and $\overline{\Xi}^+$ spectra are compatible. We estimate the systematic error for all the inverse slope parameters to be around 10%.
The yields for Ξs and Ωs, extrapolated to full p_T by using the fitted slopes, are shown on the left side of Fig.2 and compared with the corresponding values measured by NA57 at 160 A GeV/c in the same centrality range.

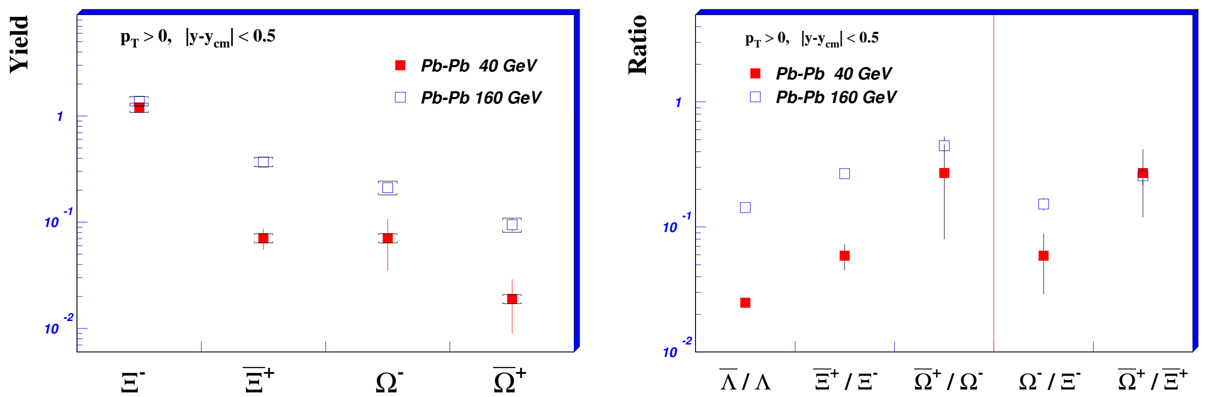

Figure 2. Particle yields and ratios in 40 and 160 A GeV/c Pb-Pb collisions.

For Ω^- and $\overline{\Omega}^+$ the extrapolation has been done by using the common slope given above. Bracket symbols in the plot indicate the systematic errors.
The central Ξ^- production for central Pb-Pb collisions stays roughly constant when going from the top SPS energy to 40 A GeV/c, while the production of $\overline{\Xi}^+$, Ω^- and $\overline{\Omega}^+$ is significantly reduced at the lower interaction energy.
Ratios involving the measured particles are shown in Fig.2 (right-side). The $\overline{\Lambda}/\Lambda$ ratio has not been corrected for acceptance and efficiency: the correction is expected to be small due to the symmetry of the NA57 apparatus. When going from 160 to 40 A GeV/c the anti-hyperon to hyperon ratios decrease, the effect being larger for Λs. For the mixed ratios, a reduction of about a factor 3 can be seen for the Ω^-/ Ξ^- ratio, while the $\overline{\Omega}^+$/ $\overline{\Xi}^+$ ratio stays about the same.

4. CONCLUSIONS AND OUTLOOK

The results from NA57 on hyperon production at 40 A GeV/c have been presented and compared with those corresponding to 160 A GeV/c Pb-Pb collisions in the same centrality range. The Ξ^- yield stays roughly constant while the production of $\overline{\Xi}^+$, Ω^- and $\overline{\Omega}^+$ production are reduced by factors 3 to 5 when going to the lower interaction energy. The anti-hyperon to hyperon ratios also decrease when going from 160 to 40 A GeV/c: the effect is largest for the Λ.
The ongoing correction procedure will provide the yields and the inverse slopes for Λ and $\overline{\Lambda}$ samples. The analysis of the p-Be data at 40 GeV/c collected in 1999 and 2001, necessary to measure the enhancement factors at 40 A GeV/c, is also currently under way.

REFERENCES

1. F. Antinori *et al.*, Nucl. Phys. **A661** (1999), 130c.
2. V. Manzari *et al.*, these Proceedings.
3. J. Rafelski and B. Müller, Phys. Rev. Lett. **48** (1982), 1066.
4. R. Caliandro *et al.*, NA57 Proposal, CERN/SPSLP 96-40, SPSLC/P300.
5. V. Manzari *et al.*, J. Part. Phys. G: Nucl. Part. Phys. **25** (1999), 473.
6. F. Antinori *et al.*, The European Physical Journal **C 18** (2000), 57.
7. F. Antinori *et al.*, The European Physical Journal **C 14** (2000), 633.
8. K. Fanebust *et al.*, J. Phys. G: Nucl. Part. Phys. **28** (2002), 1607.