Hyperon and negative particle production at central rapidity in proton-Beryllium interactions at 158 GeV/c

Presented by D. Elia for the WA97 collaboration:

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A study of the strangeness enhancement in Lead-Lead collisions with respect to proton-induced reactions is being carried out at the CERN SPS by the WA97 experiment: up to now, data from proton-Lead collisions have been used as a reference sample. In this paper we report on a study of particle production in proton-Beryllium collisions. These collisions are expected to constitute a better reference sample than p-Pb, because of the lighter target. The analysis of hyperon and negative particle production is presented and the results are compared with those previously obtained from Pb-Pb and p-Pb collisions.

1. EXPERIMENT WA97 AT CERN SPS

The WA97 experimental apparatus has been presented in [1]: a detailed description is given in [2].

The main detector is a telescope consisting of 7 silicon pixel detector planes

(75 × 500 μm^2 cell size) and 10 silicon microstrip planes (50 μm pitch) used to track charged particles in the uniform 1.8 Tesla magnetic field of the OMEGA spectrometer. The telescope cross section is 5 × 5 cm^2; it has been placed 60 cm and 90 cm downstream of the target in Pb-Pb and proton-nucleus runs respectively .

The trigger for the Pb-Pb runs has been described in [2]. In the proton-nucleus runs scintillator counters placed immediately in front of and behind the telescope have been used to require at least two tracks entering the telescope (two-tracks or *"level 2"* trigger), in order to increase the statistics of V^o events. Data have been also collected requiring at least one track entering the telescope (one-track or *"level 1"* trigger) to study the production of negative particles and to determine the *level 2* trigger efficiency.

For proton-nucleus data taking, 8% interaction length targets have been used. In order to define event-by-event the main interaction vertex in the p-Be run, the position of the beam track was measured by an array of 10 microstrip detectors.

2. DATA ANALYSIS

2.1. Selection of negative particles (h^-)

In order to achieve a good definition of the main interaction point for each event with a reconstructed beam, a vertex position has been defined by minimising the distance in space between the negative tracks and the beam track. The closest approach position along the beam and the distance of the two tracks at this closest approach point have been used to select tracks coming from the primary vertex.

Out of the full *level 1* sample, a representative sample of 2650 h^- has been weighted to account for acceptance and reconstruction losses. The size of this sample is limited by the CPU time required by the Monte-Carlo based weighting procedure.

2.2. Selection of hyperons

The Λ, Ξ^- and Ω^- hyperons and the corresponding antiparticles have been identified by reconstructing their decays into final states containing only charged particles. The hyperon signal extraction has been performed according to the same procedure as used for p-Pb and Pb-Pb data, already discussed in [3,4]. The production vertex, as for negatives, has been calculated for each candidate by minimising the distance in space between the hyperon and the beam track. The mass resolution is better than 6 MeV (FWHM) for all reconstructed hyperons.

In table 1 the hyperon statistics used for this paper is reported. The weighting procedure has been applied to the full Ξ and Ω samples and to representative sub-samples of Λ and $\overline{\Lambda}$.

Table 1
Statistics of the selected hyperons

	Λ	$\overline{\Lambda}$	Ξ^-	$\overline{\Xi}^+$	$\Omega^- + \overline{\Omega}^+$
Nr. of particles	119,320	34,349	397	157	33

3. RESULTS AND COMPARISONS

The acceptance windows for hyperons and negative particles in the p-Be data are shown in fig.1.

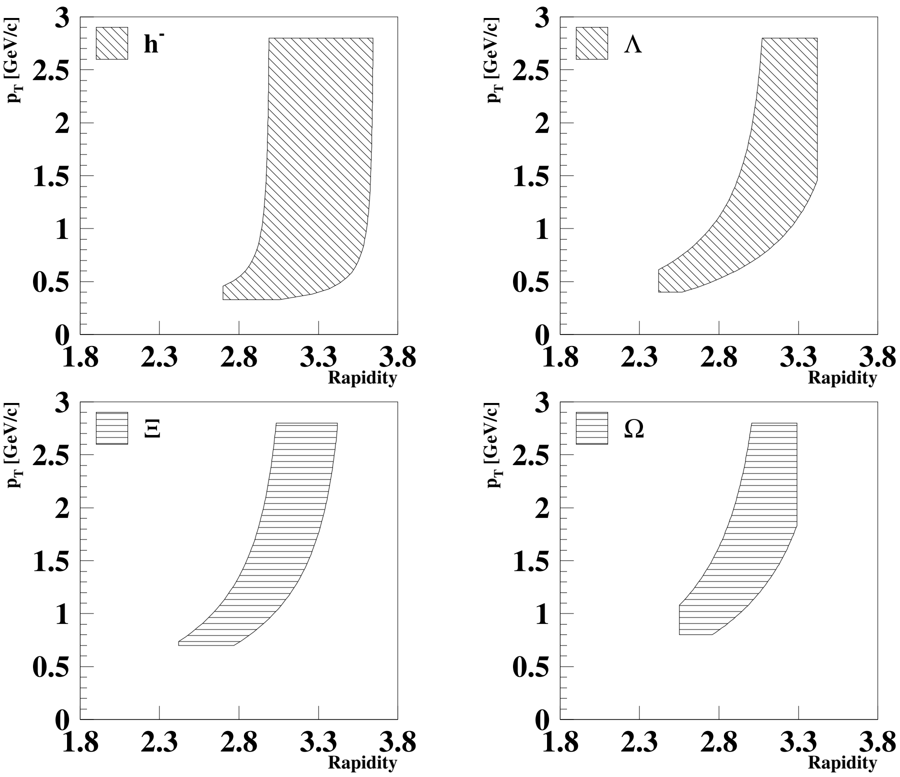

Figure 1. *Hyperon and negative particle acceptance windows.*

The differential distributions in transverse mass for all the analysed particle species have been fitted in their respective acceptance windows using the following expression:

$$\frac{dN}{dm_T} = A\, m_T^{\alpha} \exp\left(-\frac{m_T}{T}\right) \qquad (1)$$

The maximum likelihood method has been used to perform the fit.

For the presented analysis the distribution in rapidity has been assumed to be constant for $|y - y_{cm}| < 0.5$; the systematic error introduced by this approximation has been estimated to be within the quoted statistical errors[5].

The inverse slope parameters T obtained in p-Be data for all the particle species have been reported in table 2, both for α equal 3/2 and 1. For a complete comparison of these inverse slopes with those obtained in p-Pb and Pb-Pb collisions see ref.[1].

The WA97 experiment aims to study the evolution of particle yields with the collision centrality. To this purpose we estimate the number of nucleons participating in the collision N_{part}. Silicon microstrip detectors present in the experimental set-up for lead-lead collisions give an event-by-event measurement of the charged multiplicity that can be related to N_{part} as described in ref.[3]; for p-A data the number of participants has been estimated as the average for minimum bias collisions.

Table 2
Inverse slope parameters in MeV for p-Be interactions

	$\alpha = 3/2$	$\alpha = 1$
h^-	164 ± 3	186 ± 3
Λ	170 ± 2	180 ± 2
$\overline{\Lambda}$	151 ± 2	157 ± 2
Ξ^-	191 ± 12	202 ± 13
$\overline{\Xi}^+$	173 ± 16	182 ± 17
$\Omega^- + \overline{\Omega}^+$	163 ± 36	169 ± 40

The analysis has been performed by dividing the multiplicity spectra into four bins and evaluating an average N_{part} for each of them[6]; then particle production yields per event Y have been calculated according to the following extrapolation:

$$Y = \int_0^\infty dp_T \int_{y_{cm}-0.5}^{y_{cm}+0.5} dy \frac{d^2N}{dp_T dy} \tag{2}$$

which makes use of the inverse slopes found by fitting expression (1) to the data, and assuming the rapidity distribution to be constant for $|y - y_{cm}| < 0.5$. Corrections for feed-down from weak decays have not been taken into account in the Λ and Ξ yield estimation: the effect of such a contribution is expected to be less than 10% in the geometry of the WA97 experiment. In fig.2 particle yields per event are shown as a function of the average N_{part}. Particle species with at least one common valence quark with the nucleon (h^-, Λ and Ξ^-) are shown separately from the others ($\overline{\Lambda}$, $\overline{\Xi}^+$ and Ω), because of their different production features.

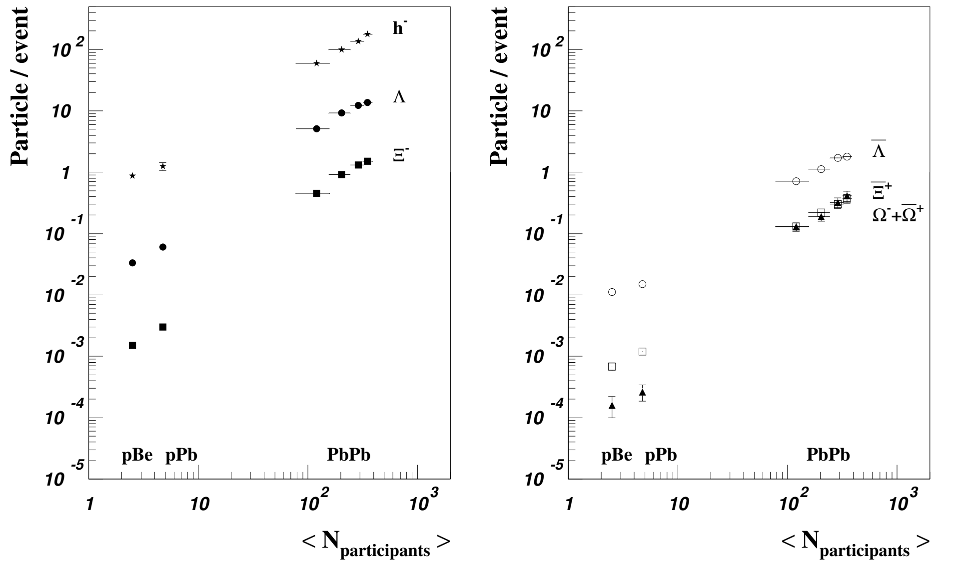

Figure 2. *Particle yields vs* N_{part}.

Horizontal error bars for Pb-Pb points correspond to the FWHM of the N_{part} distribution in each centrality bin[6]. In each of these two groups all the yields show a steady increase with centrality when going from p-Be to Pb-Pb. Such an increase is larger for multiply strange particles, following the hierarchy $\Xi^- > \Lambda > h^-$ and $\Omega^- + \overline{\Omega}^+ > \overline{\Xi}^+ > \overline{\Lambda}$. This is illustrated in fig.3 showing the yields normalized to the p-Be values.

It can be also noticed that both from p-Be to p-Pb and within the N_{part} range covered by Pb-Pb data, the increase of all the yields is compatible with being proportional to the number of participants as defined in [6]. The full line corresponds to the yield curve proportional to N_{part} drawn through the p-Be points.

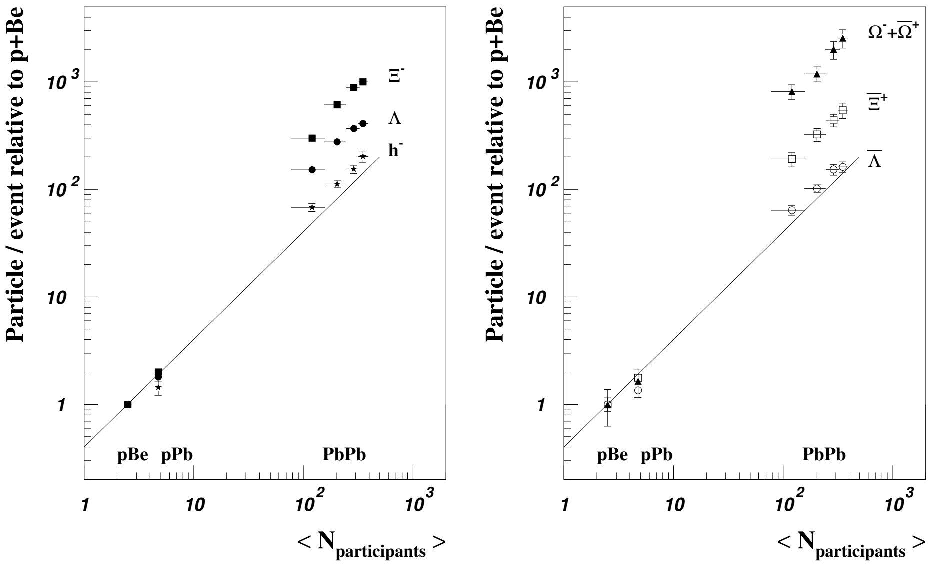

Figure 3. *Particle yields vs N_{part} with respect to p-Be yields.*

4. SUMMARY AND CONCLUSIONS

Results from the analysis of p-Be interactions at 158 GeV/c at the CERN SPS have been presented and compared with those found for p-Pb and Pb-Pb.

Strange particle yields appear to scale linearly with the average number of participants for proton-induced reactions, while going from p-A to central Pb-Pb interactions the increse is faster than expected from direct proportionality with N_{part}. Such an increase becomes more pronounced with the strangeness content of the particle and is greater than an order of magnitude for Ωs.

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