Strange Baryon production in p-Pb collisions at 158 GeV/c : a comparison with VENUS model

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Abstract

Λ, Ξ and Ω yields measured by the WA97 experiment at central rapidity in p-Pb interactions at 158 GeV/c are compared to those predicted by VENUS 4.12. The VENUS model, although in reasonable agreement with the Λ and the negative particle data, fails to reproduce the data on multistrange baryons and anti-baryons.

1 Introduction

The observation of strange particles yields provides one of the most promising ways to study the properties of the nuclear matter at very high energy densities. In particular, it was suggested that the production of multistrange baryons would be enhanced if a Quark Gluon Plasma is formed [1]. It this therefore necessary to compare nucleus-nucleus data with those from proton-proton and proton-nucleus collisions. It is also clear from the experimental data that nucleus-nucleus interactions cannot be described by a simple superposition of nucleon collisions, and that the nuclear medium has a strong influence on experimental quantities. A number of Monte Carlo models, based on conventional interactions and including the full dynamics of ultrarelativistic nuclear collisions, have been proposed. Such models are able to produce quantitative predictions, and so they, in principle, constitute a useful tool to analyze experimental data. Most of them are claimed to be able to reproduce the observed nucleus-nucleus features, at least after a fine tuning of some internal parameters. However, they should be capable of describing nucleus-nucleus, proton-proton and proton-nucleus interactions.

In this paper we shall compare the p-Pb data collected by the WA97 collaboration [2] with the VENUS model predictions.

2 The VENUS model

The VENUS model, by Klaus Werner [3], is one of the most frequently used event generators, and one of the best microscopic models available, as was stated at the Quark Matter '97 conference. A complete description of the model can be found in reference [3]; here we shall present a summary of the main ideas.

The model is based on the phenomenological Gribov-Regge Theory (GRT) of hadron-hadron and nucleus-nucleus interactions. According to GRT, the basic interaction mechanism is Pomeron exchange, where a Pomeron need not describe a real particle, but has some well defined properties. The objects which interact are strings, which can both describe a diquark system, or a quark plus a diquark. After the interactions the final strings are allowed to decay according to rules based on general principles such as locality and gauge invariance.

The model contains some parameters which are tuned in order to reproduce the experimental quantities. For example, string decay is governed by a set of parameters tuned to reproduce lepton-nucleus data, whereas string interaction parameters come from hadron-hadron data. When nuclear interactions are involved, additional parameters are introduced to describe the nuclear density and the rescattering process for particles in nuclear matter.

VENUS is able to reproduce the main features of events, like multiplicity, rapidity (Y) and transverse momentum ($p_{\rm T}$) distributions for pions and nucleons, in hadron-hadron, hadron-nucleus and nucleus-nucleus interactions, at both Brookhaven and CERN energies [3]. VENUS is also able to reproduce Λ and K multiplicity and rapidity distributions in proton-proton, proton-nucleus, S-S and S-Au interactions. It is important to stress that the strangeness enhancement provided by VENUS comes directly from the model, and no special parameter tuning is required.

For the Λ transverse momentum distribution VENUS produce a flatter spectrum and correspondingly a higher inverse slope parameter than the data for the proton-xenon interactions [4]. This feature was already noted by Werner in his report [3].

3 The method

We have generated a sample of 500 000 p-Pb events at 160 GeV/c using the standard VENUS 4.12 version, without modifications of internal parameters. We allow all resonances to decay, and we keep in the final state all the stable particles up to Ωs (decay options in the code: 'ndecax'=00000000, 'ndecay'=01111110). These Monte Carlo events are compared with data from WA97 experiment.

Details on the experimental sample selections, on the set-up and on the experimental procedure can be found in reference [2], and in references [5], [6] presented at this conference.

We have compared the inverse slope of the transverse mass distribution, and the yields (i.e. the number of particles per event) for strange baryons (Λ, Ξ and Ω), their anti-particles and negative charged particles. We have restricted the comparison to our acceptance windows, in order to avoid problems due to extrapolation, and we have taken into account our experimental acceptance and recostruction efficieny (see references [5], [6]). Therefore, we have evaluated VENUS yields simply by counting particles in these acceptance windows. Such windows are shown in figures 1 and 2, where the entries are the numbers of particles generated by VENUS in each region. For the inverse slope comparison we have applied a fit procedure to VENUS data in the same way as was done for the experimental data. Details on the procedure are described in the others WA97 contributions to these proceedings ([5], [6]). We have parametrised the transverse mass distributions using the function :

$$\frac{dN}{dm_{\rm T}} \propto m_{\rm T}^{a} \exp\left(\frac{-m_{\rm T}}{T}\right)$$

where $m_{\rm T} = \sqrt{m^2 + p_{\rm T}^2}$ is the transverse mass, T is the inverse slope parameter and $a = 3/2$. We have also assumed $m = m_\pi$ for all negative particles, both in VENUS and in the real data.

4 The results

4.1 Inverse slope

In figure 3 the inverse slopes for the different particles are shown, for VENUS (open circles) and WA97 data (black dots). The horizontal scale separates the different particles, with no relation to their masses. We have combined Ω and $\overline{\Omega}$ because of the low statistics in the experimental sample.

We see that VENUS predicts values which are too high for the inverse slopes of Λ and Ξ, whereas there is agreement with data for the other particles. We note that this feature was already reported for Λ in p-Xe interactions [3]. We also note that in general the inverse slopes of strange baryons provided by VENUS are larger than those for strange anti-baryons (the values for Ω and $\overline{\Omega}$ are not shown in the figure).

4.2 Yields

Figure 4 shows the number of particles per event, for both VENUS and WA97 data (symbols are as in the previous figure). The vertical scale is logarithmic. Error bars for VENUS are contained in the circle dimensions.

We see that VENUS reproduces well the multiplicity for negatives and Λs. The agreement is fair for $\overline{\Lambda}$, and is bad for multi-strange particles, where VENUS overestimates significatively with respect to the data. The differences increase from Ξ to Ω, and from particles to anti-particles, being one order of magnitude for Ω and even more for $\overline{\Omega}$.

5 Conclusions

We have shown that VENUS, version 4.12, with standard parameters is able to reproduce the multiplicity of negatives and Λs for p-Pb events in the WA97 acceptance windows.

The inverse slope parameters are also in agreement with WA97 data, with the exception of Λ and Ξ. We note that the inverse slopes of strange baryons predicted by VENUS are significatively larger than those for strange anti-baryons, whereas similar values are seen for baryons and anti-baryons in the data.

VENUS fails to reproduce multi-strange particle yields. Ξ and Ω multiplicities are overestimated with respect to the real data by one order of magnitude or more, the differences being larger going from Ξ to Ω and from particles to anti-particles.

References

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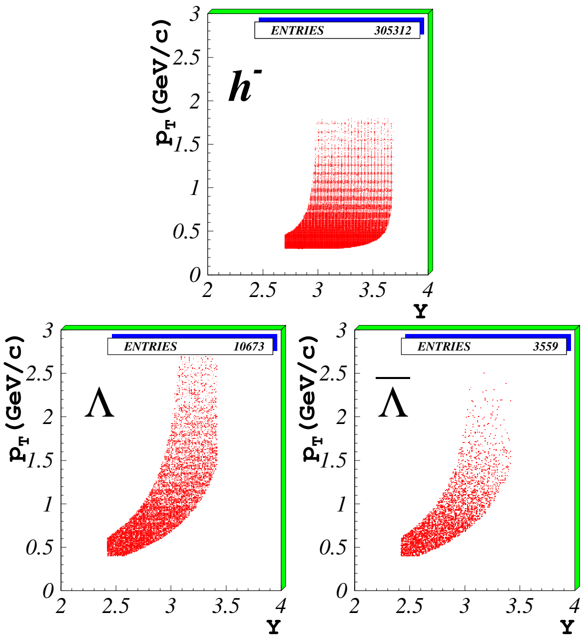

Figure 1: WA97 acceptance windows for negatives, Λ and $\overline{\Lambda}$.

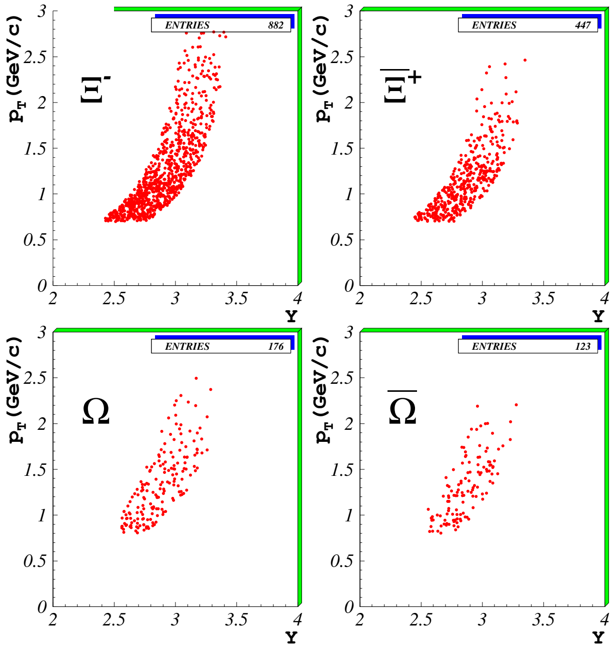

Figure 2: WA97 acceptance windows for Ξ^-, $\overline{\Xi}^+$, Ω and $\overline{\Omega}$.

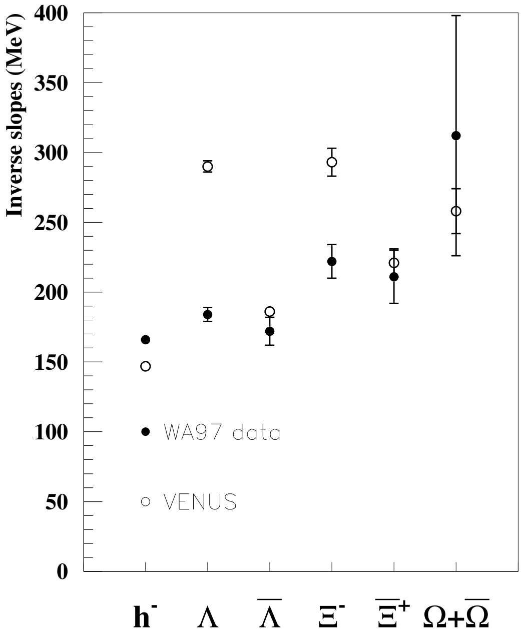

Figure 3: Inverse slope parameters.

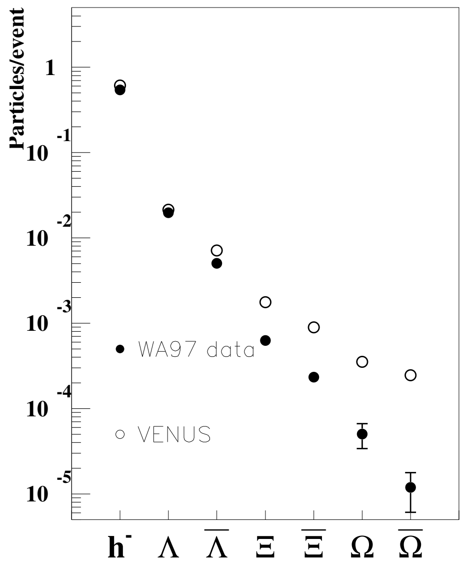

Figure 4: Yields.