Results on baryon antibaryon correlations in $e^+e^-$-annihilation*

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Abstract. The correlations between $p\bar{p}$, $A\bar{A}$, $\Xi^-\Lambda$ and $A(1520)\bar{A}$ baryons have been measured in $e^+e^-$ continuum events and in direct $Y$ decays. The observed correlations exclude the production of point-like di-quark-antidiquark pairs as the dominant source of baryons. Information concerning angular momentum compensation follows from the observed $A(1520)\bar{A}$ correlation.

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1 Introduction

Baryon production in $e^+ e^-$ annihilation has been investigated by several experiments, mainly running at center-of-mass energies around 30 GeV [1]. These studies have been supplemented recently by an analysis of inclusive baryon production in a high statistics data sample obtained at energies in the $\Upsilon$ mass region, where production rates for most octet and decuplet hyperons [2] and the orbitally excited $A(1520)$ state [3] were obtained. The interest in this work lies in the unsettled question of the mechanism for baryon production in fragmentation processes.

In many fragmentation models, baryon production requires the somewhat ad hoc introduction of quarkonia as additional partons [4]. From the diquark model one can expect strong correlations between baryon-antibaryon ($BB$) pairs, a prediction which can be tested by analysing both kinematical and flavour correlations between such pairs. An alternative approach is to model baryon production via independently produced quarks generated by colour fluctuations in an onedimensional colour flux-tube [5]. This model is usually referred to as the popcorn mechanism, since meson ($M$) production “between” the baryon and antibaryon ($BMB$ configuration) is allowed, diminishing correlations between the baryons.

Both models are implemented in the Lund event generator [6], where an adjustable parameter $p = BMB/(BB + BMB)$ allows for a continuous variation between a pure diquark model ($BB$ only) and a 100% $BMB$ configuration. Experimentally, two approaches can be used to distinguish the models. The most direct method is to search for correlations in the quantum numbers of baryons and antibaryons. Unfortunately $p$ and $A$ baryons*, while most easily accessible to experiments, are largely the decay products of heavier baryon states [2], and therefore provide only indirect information on quantum number correlations. The situation is somehow better for kinematical correlation studies, since baryons originating from the decays of heavier states usually carry most of the mother particle’s momentum due to their large mass.

Correlation studies have already been published by several experiments [7]. In comparison with model predictions most of these data favour a large “popcorn” contribution to baryon production. This result is qualitatively supported by an investigation of strangeness and spin suppression in inclusive production of heavier hyperon states [2]. No extra strangeness suppression was seen for baryons compared to the known $SU(3)$ breaking for mesons, and within the experimental errors spin and strangeness suppression were shown to be uncorrelated. Neither of these observations is naturally expected in a diquark model, but they are consistent with predictions of baryon production from independent quarks. In this paper we report further evidence for a large popcorn contribution, through studies of both kinematical correlations of $p\bar{p}$ pairs, and quantum number correlations of $A\bar{A}$, $\Xi^-\bar{\Lambda}$ and $A(1520)\bar{A}$ pairs. It turns out that none of the measurements alone is able to give unique constraints to the models, and therefore physical interpretations require in most cases a more comprehensive view of different experimental results.

2 Data analysis

The data were collected with the ARGUS detector on the $\Upsilon(1S), \Upsilon(2S)$ and $\Upsilon(4S)$ resonances and in the nearby continuum with integrated luminosities of 25.7, 29.3, 95.4 and 42.3 pb$^{-1}$, respectively. A detailed description of the detector, its trigger and particle identification capabilities can be found in [8].

The data were divided into two samples in order to allow for separate analyses of gluon and quark fragmentation. For the study of low statistics $\Xi^-\bar{\Lambda}$ and $\Lambda(1520)\bar{A}$ signals the $\Upsilon(4S)$ was treated as continuum and the $\Upsilon(1S)$ and $\Upsilon(2S)$ data were combined. For the higher statistic samples only $\Upsilon(1S)$ and continuum data were used, in order to avoid additional systematic uncertainties.

Multihadron events were selected by requiring at least 3 tracks from a reconstructed main vertex or 3 tracks, not necessarily pointing to a common vertex, but having more than a total of 1.7 GeV energy deposited in the shower counters. Charged tracks were selected by requiring that their momentum transverse to the beam direction be greater than 60 MeV/c, and restricting their polar angle to $|\cos \theta| < 0.92$. Particles assumed to originate from strong interaction processes were required to point within 7 standard deviations of the main vertex. The identification of charged particles was performed by measurements of the specific ionization loss $(dE/dx)$ and of time-of-flight. Both measurements were combined into a normalized likelihood ratio. A given particle hypothesis was accepted if the corresponding likelihood value exceeded 5%.

$A$ hyperons were reconstructed by a secondary vertex fit. The flight direction of the $A$ candidate was restricted to $|\cos \theta| < 0.85$. Furthermore, only $p\pi^-$ combinations with a scaled momentum $x_p = p_A/p_{max}$ $> 0.1$ were considered, since the acceptance is small below this value. In order to reduce combinatorial background to the $A$ signal, the radial distance of the decay vertex, $R_{xx}$, from the beam line was restricted to the interval $4 \text{ cm} < R_{xx} < 40 \text{ cm}$. Converted

* References to a specific state are to be interpreted as also implying the charge conjugate state