Measurement of the production rates of charged hadrons in $e^+e^-$-annihilation at the $Z^0$

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Abstract. The inclusive production rates of $\pi^\pm$, $K^\pm$ and $p\bar{p}$ in $Z^0$ decays have been measured with the OPAL detector at LEP. Using the energy loss measurement in the jet chamber, the momentum range up to the beam energy (45.6 GeV/c) has been covered. Differential cross sections and total particle yields are given. Comparisons of the inclusive momentum spectra and the total rates with predictions of the JETSET and the HERWIG Monte Carlo model are presented. The total single rates are found to be $17.05_{-0.43}^{+0.43}$ $\pi^\pm$, $2.42_{-0.13}^{+0.13}$ $K^\pm$ and $0.92_{-0.11}^{+0.11}$ $p\bar{p}$ per hadronic event. Predictions of JETSET for cross sections and total rates agree very well for $\pi^\pm$; however, for momenta greater than 4 GeV/c, $K^\pm$ rates are underestimated and $p\bar{p}$ rates are overestimated. Combined with data of other particle species there is evidence that the peak positions in the $\xi = \ln(1/x_p)$ distributions show a different mass dependence for mesons and baryons. However, both JETSET and HERWIG Monte Carlo predictions agree with the observed data.

1 Introduction

The knowledge of the hadronic particle composition of the $q\bar{q}$ final state in $e^+e^-$ annihilation is important for understanding the fragmentation of quarks and gluons into hadrons. No exact theoretical prescription exists for this process yet. Instead, a variety of phenomenological models have been developed. At present, those used most commonly are the string fragmentation model [1] and the cluster fragmentation model [2]. Another approach to describing the hadron momentum spectra combines the modified leading log approximation (MLLA) [3] of QCD with the concepts of local parton hadron duality (LPHD) [4].

In this paper measurements of the momentum spectra of the charged hadrons $\pi^\pm$, $K^\pm$ and $p\bar{p}$ resulting from $Z^0$ decays into multihadronic final states at centre of mass energies $E_{CM}$ of 91.2 GeV are presented. The data obtained are then compared with predictions from the JETSET [5] and the HERWIG [6] Monte Carlo generators with optimized parameters* [7], representing the string and the cluster fragmentation models, respectively. Similar measurements in $e^+e^-$ annihilations at $\sqrt{s} = 10$ GeV [8, 9] and around $\sqrt{s} = 29$ GeV [10–13] have been previously reported.

Production rates of neutral pions and $\eta$ at LEP have been published by the L3 collaboration [14, 15]. Neutral kaon and lambda production rates have been published by the OPAL [16, 17] and the DELPHI collaborations [18]. Production rates for $K^*(892)^\pm$ and $\Xi^-$ have been published by the OPAL collaboration [19, 17]. These data are used later for comparison with the MLLA predictions and the predictions of the JETSET and HERWIG Monte Carlo generators.

* "JETSET" and "HERWIG" throughout this paper stand for "JETSET 7.3 and HERWIG 5.5 with optimized parameters tuned by OPAL in order to describe the measured global event shape distributions" unless otherwise indicated.