ANGULAR INTERMITTENCY AND ANALYTICAL QCD PREDICTIONS

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Abstract

We present a comparison of local multiplicity fluctuations in angular phase-space intervals with analytical first-order QCD predictions. The data are based on 810k hadronic events at $\sqrt{s} \simeq 91.2$ GeV collected with the L3 detector at LEP during 1994.

Recently, progress has been made to derive analytical QCD predictions for angular intermittency [1–3]. Attempts have been undertaken by the DELPHI Collaboration to compare the predictions of [1] with the data for hadronic Z^o decay [4].

In this paper we extend this study and present a first quantitative comparison of the theoretical first-order QCD predictions [2,3] with the L3 data, emphasizing the behavior of normalized factorial moments of orders $q = 2, \ldots, 5$ in angular phase-space intervals.

QCD predictions have been obtained [2,3] for normalized factorial moments (NFMs) $F_q(\Theta) = \langle n(n-1)\ldots(n-q+1)\rangle/\langle n\rangle^q$, which show following scaling behavior $F_q(\Theta) \propto (\Theta_0/\Theta)^{(D-D_q)(q-1)}$. For the one-dimensional case ($D = 1$), Θ_0 is the opening half angle of a cone around the jet-axis, Θ is the angular half-width window of rings around the jet-axis centered at Θ_0 and n is the number of particles in this window. QCD expectations for D_q are as follows [2, 3]:

1) In a fixed coupling regime of the Double Leading Log Approximation (DLLA), $D_q = \gamma_0(Q)(q+1)/q$, where $\gamma_0(Q) = \sqrt{2C_{\mathrm{A}}\alpha_s(Q)/\pi}$ is the anomalous QCD dimension calculated at $Q \simeq E\Theta_0$, $E = \sqrt{s}/2$, and $C_{\mathrm{A}} = 3$ is the gluon color factor. $\alpha_s(Q)$ is evaluated according to the first order QCD with $n_f = 5$ flavors.

2) In a running-coupling regime of DLLA, the D_q have the form

$$D_q \simeq \gamma_0(Q)\frac{q+1}{q}\left(1+\frac{q^2+1}{4q^2}z\right) \quad (1), \qquad D_q \simeq 2\,\gamma_0(Q)\frac{q+1}{q}\left(\frac{1-\sqrt{1-z}}{z}\right) \quad (2),$$

were $z = \ln(\Theta_0/\Theta)/\ln(E\Theta_0/\Lambda)$. Expressions (1) and (2) were obtained in [2] and [3], respectively.

3) In the Modified Leading Log Approximation (MLLA), (2) remains valid, except that $\gamma_0(Q)$ is replaced by an effective $\gamma_0^{\mathrm{eff}}(Q)$ depending on q [2].

For our comparison of the data with the theoretical predictions quoted above, we will use the following parameters: $\Theta_0 = 25^0, \Lambda = 0.16$ GeV. The first parameter is free. Its value is chosen to make our study comparable with the DELPHI analysis [4]. The value of Λ chosen is that found in our most recent determination of $\alpha_s(m_Z)$ [5].

The comparison of the analytical QCD predictions to the data is shown in Fig. 1. The data are corrected for detector imperfections, initial-state photon radiation, Bose-Einstein correlations and Dalitz decays using Monte Carlo. The predictions lead to the saturation effects seen in the data, but significantly underestimate the observed signal for $q = 2$. The reason for the

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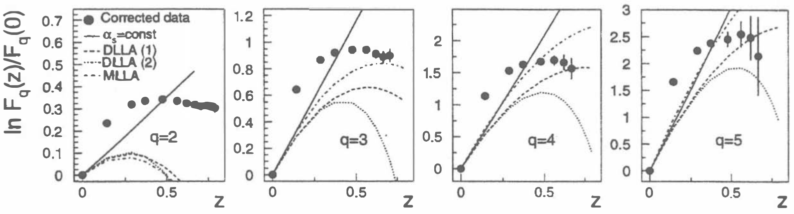

Figure 1: *The analytical QCD predictions for* $\Lambda = 0.16$ GeV*: 1)* $\alpha_s = const$ *; 2) DLLA (eq. (1)); 3) DLLA (eq. (2)); 4) MLLA.*

saturation effect seen on the QCD predictions is the dependence of $\alpha_s(Q)$ on Θ. The fixed coupling regime (solid lines in Fig. 1) approximates the running coupling regime for small z, but does not exhibit the saturation effect seen in the data. The MLLA predictions do not differ significantly from the two DLLA result for running coupling regime.

We have varied Λ in the range of $0.04 - 0.25$ GeV. We found that the disagreement observed is valid for relatively large values of Λ as well as for small values (down to $\Lambda = 0.04$ GeV). In the latter case, a reasonable estimate for the second-order NFM can be reached, consistent with the DELPHI conclusion [4]. However, our analysis shows that, in this case, the theoretical higher-order NFMs overestimate the data.

Note that the disagreement for the second-order NFMs can be reduced by considering the second-order expression for $\alpha_s(Q)$ or by replacing $n_f = 3$, instead of $n_f = 5$. This leads to a decrease of the $\gamma_0(E\Theta_0)$. However, also in this case good agreement cannot be achieved for higher-order NFMs.

Conclusion. The analytical first-order perturbative QCD predictions are shown to be in disagreement with the local fluctuations observed for hadronic Z^o decay.

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