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Measurement of QCD Parameters by Using the Single Dressed Gluon Approximation

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1. Event shape variables in e^+e^- annihilation provide an ideal testing ground to study Quantum Chromodynamics (QCD) and have been measured and studied extensively in the last two decades. In particular, event shape variables are interesting for studying the interplay between perturbative and non-perturbative dynamics [1–3]. Power corrections in QCD have been the subject of many interesting theoretical developments in the recent years [4], especially concerning observables that do not admit an operator product expansion [5–14].

For these observables the available [15, 16] the n-th moment of an event shape observable is defined by:

$$\langle y^n \rangle = \int_0^{y_{\max}} y^n \frac{1}{\sigma_{\rm tot}} \frac{d\sigma}{dy} dy, \tag{1}$$

$$\langle y^n \rangle = \langle y^n \rangle_{pt} + \langle y^n \rangle_{np}. \tag{2}$$

For an observable the perturbative prediction is [17, 18]:

$$\langle y \rangle_{PT} = \overline{A}_f \left(\frac{\alpha_s(\mu)}{2\pi}\right) + \\ + \left(\overline{B}_f + \overline{A}_f \beta_0 \log\left(\frac{\mu^2}{Q^2}\right)\right)\left(\frac{\alpha_s(\mu)}{2\pi}\right)^2. \tag{3}$$

The $\overline{A}_f$ and $\overline{B}_f$ coefficients have been given in [19]. For instance, non-perturbative scales λ_p parameterzing power corrections to $\langle y \rangle_{np}$ can be defined by [20, 10].

$$\langle y \rangle = \langle y \rangle_{PT} + \frac{\lambda_P}{Q^P}. \tag{4}$$

In the context of event-shape variables in e^+e^- we mention the case of the longitudinal cross-section [12, 21–25].

The aim of this paper is to study this model qualitatively and quantitatively by measurements of the strong coupling constant in perturbative and the non-perturbative regions.

The outline of the article is as the following. In Sect. 2, we consider the event shape variables used in this analysis. Sect. 3 describes the perturbative QCD predictions as well as the single dressed gluon method which describes the hadronization process. We present our results in Sect. 4. Finally Sect. 5 is devoted to our conclusions and discussions.

2. Event shape variables measure geometrical properties of hadronic final states at high energy particle collisions.

The most common observables (y) are: Thrust [3], the heavy jet mass, the total and wide jet broadening [4] and the C parameter [26, 27].

3. The purpose of this paper is to examine, in the framework of the SDG approximation, running-coupling effects and power-corrections to higher moments of the event shape variables [28, 29]. This approximated series diverges and various regularizations differ by definite powers of the energy [10]:

$$\langle y^1 \rangle = \langle y^1 \rangle_{PT} + \frac{\nu_1}{Q}. \tag{5}$$

As we mentioned previously, our main issue in this paper is to find the coupling constant in perturbative region as well as the non-perturbative parameter (ν) by using above equation.

4. In this section we use the event shape variables mentioned for calculating both the strong coupling constant $\alpha_s(M_{Z^0})$ and the non-perturbative parameter (ν). In our analysis we are using the real data as well as the simulated Monte-Carlo [30, 31].

Figure 1 shows the mean value of $\langle (1-T)^n \rangle$ up to the $n = 3$ order. As the diagrams indicate, all distributions tend to decrease by increasing the centre of mass energy, however they do not vanish [32]. We see that the distribution of SDG approximation (dash line) follows the same trend as those for the simulated Monte-Carlo data. By fitting NLO theory, our results are tabulated in Table 1.

We do a similar analysis and calculation for other event shape variables, such as Heavy jet mass (ρ), Wide jet broadening (B_W), Total jet broadening (B_T) and C parameter (C).

5. In this article, we have calculated the strong coupling constant (α_s) in perturbative region and also

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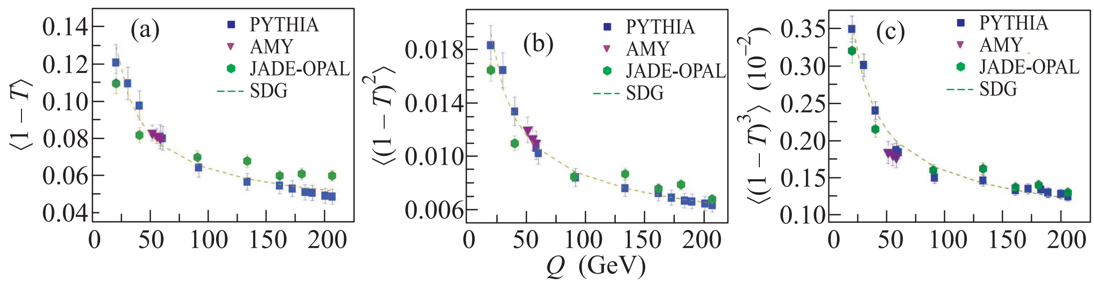

Fig. 1. (Color online) The distribution of 1-Thrust observable by fitting the SDG model up to third order

the free parameter (ν) in non-perturbative part of the QCD theory, using the Single Dressed Gluon approximation. To achieve this we employ the event shape variables $\langle 1-T\rangle$, $\langle B_W\rangle$, $\langle B_T\rangle$, $\langle\rho\rangle$, and $\langle C\rangle$. By using the Monte-Carlo generated events and also the real data we find $\alpha_s(M_{Z^0}) = 0.1215 \pm 0.003$ GeV and $\nu = 1.2685 \pm 0.0173$ GeV. This value is consistent with $\alpha_s(M_{Z^0}) = 0.1249 \pm 0.0022$ GeV obtained by JADE and OPAL experiments [18]. Our results are also in good agreement with the QCD predictions [20].

Table 1. The obtained values for the coupling constants for simulated Monte-Carlo data

$\langle(1-T)^n\rangle$	NLO	SDG	
	$\alpha_s(M_{Z^0})$	$\alpha_s(M_{Z^0})$	ν(GeV)
$n=1$	0.1560 ± 0.0043	0.1109 ± 0.0041	1.4264 ± 0.0174
$n=2$	0.1757 ± 0.0074	0.1275 ± 0.0042	1.4671 ± 0.0101
$n=3$	0.1957 ± 0.0076	0.1315 ± 0.0043	1.4743 ± 0.0097
$\chi^2/d.o.f$	1.27	1.03	1.02

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