EVENT SHAPES AT LEP

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Preliminary results from studies of the structure of hadronic events produced in e^+e^- annihilation at LEP are presented. The decrease of α_s with increasing energy is as expected in QCD

1 Introduction

Hadronic events produced in high energy e^+e^- annihilation provide a rich environment for tests of QCD predictions. The structure of these events is related to the gluon radiation occuring during the transition between the primary quarks and the hadronic final state. At LEP the energy available for quark-pair production has increased from $\sqrt{s} = 91$ GeV to $\sqrt{s} = 183$ GeV in 1997, allowing to measure the energy dependence of event shape variables in a single experiment.

2 Charged Particle Multiplicity

The dynamics of hadron production can be probed using the charged particle multiplicity distribution which has been found to be sensitive to the parameters of the QCD models. Figure 1 shows the charged particle multiplicity distribution measured by the L3 collaboration at $\sqrt{s} = 183$ GeV and $\sqrt{s} = 91.2$. The distributions are corrected for background using Monte Carlo on a bin-by-bin basis and for resolution and acceptance using a matrix unfolding method. Also shown in Figure 1 is the evolution of mean charged particle multiplicity with centre-of-mass energy compared to several QCD models. Also included are measurements done by other e^+e^- experiments at similar and lower centre-of-mass energies. The parameters of these models are the same at all energies. It is seen that the energy dependence of the multiplicity distribution is in agreement with the predictions of parton shower models like Jetset, Herwig, and Ariadne which include QCD coherence effects. However, parton shower models with no QCD coherence effects like Cojets or matrix element models as implemented in Jetset cannot explain the energy dependence. Cojets predicts a faster energy evolution, while the matrix element model, which has low parton multiplicity before fragmentation due to $\mathcal{O}(\alpha_s^2)$ calculation, needs retuning at each centre-of-mass energy.

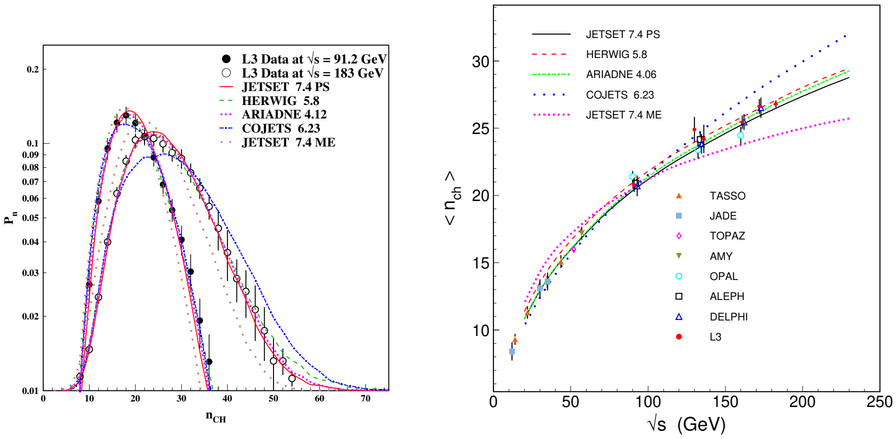

Figure 1: The charged multiplicity distribution at $\sqrt{s} = 183$ GeV and $\sqrt{s} = 91.2$ (left) and the mean charged particle multiplicity as a function of the centr-of-mass energy, compared to several QCD models (right)

3 Inclusive spectra

The phenomenon of colour coherence in QCD implies destructive interference of soft gluon emission. This gives rise to a suppression of hadron production at small momenta. The charged particle momentum spectrum is studied in terms of the variable $\xi = \ln(1/x)$, where x is the momentum scaled by the beam energy. In Fig. 2 the ξ distribution as determined by the DELPHI collaboration is shown together with data obtained at lower energies. All data in the 14-183 GeV range can be represented well by a distorted Gaussian. The peak position $\xi^\star$ is also shown in Fig. 2 for the LEP data and data at lower energy and compared to MLLA QCD predictions. It is seen that the QCD predictions calculated to the next to leading orders are in good agreement with the data.

4 Event shape variables

For the variables, thrust (T), scaled heavy jet mass (ρ), total (B_{T}) and wide (B_{W}) jet broadening variables and C-parameter, improved analytical QCD calculations are available. In Fig. 3 the data at 183 GeV from the L3 collaboration are shown for the first 4 variables. The distributions are background subtracted and corrected bin by bin for acceptance, detector and resolution effects. Also corrections for the effects of initial and final state radiation have

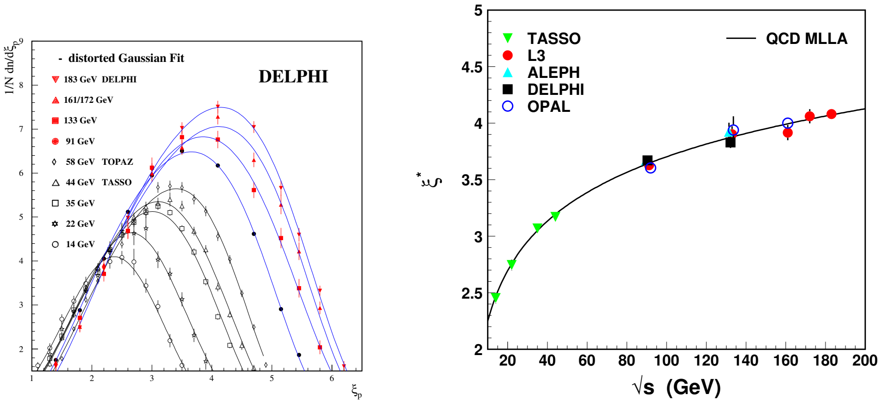

Figure 2: ξ distibution for charged particles; the line is the result of thefit with a distorted Gaussian (left) and the energy evolution of $\xi^{\star}$, where the line represents the QCD MLLA prediction (right)

been applied bin-by-bin using the PYTHIA monte Carlo generator at particle level with and without radiation. The lines represent the results from the QCD fit from which α_{s} is determined to be:

$$\alpha_{\mathrm{s}}\ (183\ \ \mathrm{GeV}) = 0.109\ \pm\ 0.003\ (\mathrm{exp})\ \pm\ 0.005\ (\mathrm{th})$$

where the first error is experimental and the second error is theoretical. This result can be compared with the L3 result obtained at the Z pole:

$$\alpha_{\mathrm{s}}\ (91\ \ \mathrm{GeV}) = 0.122\ \pm\ 0.002\ (\mathrm{exp})\ \pm\ 0.007\ (\mathrm{th})$$

The experimental systematic uncertainties are estimated by varying the energy calibration and background content. The theoretical error is dominated by the uncertainties due to uncalculated higher orders. The higher order uncertainty is estimated by using different renormalisation scales and by varying the resummation matching scheme. Also in Fig. 3 we compare the L3 data at all energies with the QCD evolution. Good agreement is seen between the data and the QCD evolution. The errors are experimental only as the theoretical errors are highly correlated between the different energy points. The points at $\sqrt{s}$ below the Z pole have been obtained from the analysis of a sample of hadronic events recorded on the Z pole but containing an observed energetic photon.

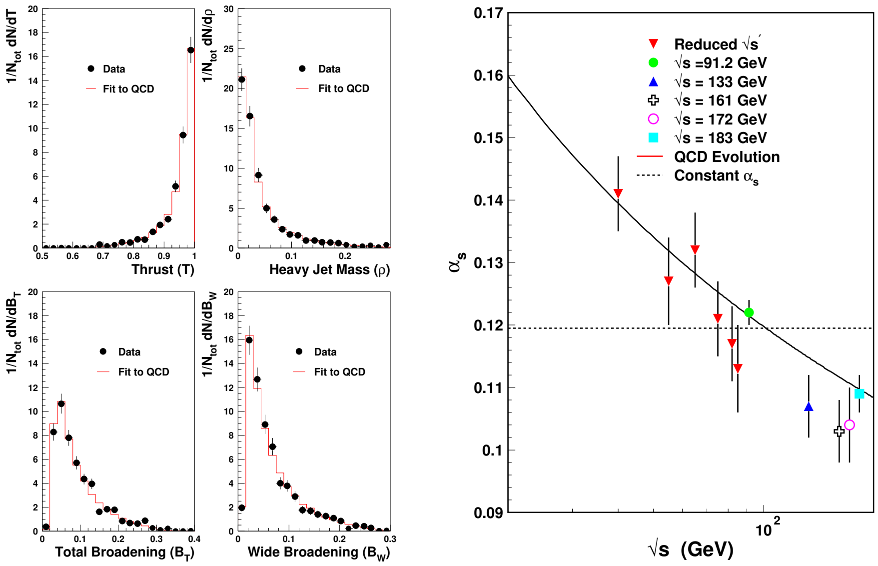

Figure 3: Measured distributions of thrust, T, scaled heavy jet mass, ρ, total, B_{T}, and wide, B_{W}, jet broadening, in comparison with QCD predictions at 183 GeV. The experimental errors include statistical and systematic uncertainties (left). α_{s} measurements from event shape distributions as a function of the centre-of-mass energy. Only the experimental error is shown. The solid and dashed lines are fits with the energy dependence of α_{s} as given by QCD and with constant α_{s}, respectively (right).

Acknowledgments

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