STUDY OF THE STRUCTURE OF HADRONIC EVENTS AND DETERMINATION OF α_s AT $\sqrt{s} = 130GeV$ AND $136GeV$

For the L3 Collaboration
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We present a study of the structure of hadronic events recorded by the L3 detector at center-of-mass energies of 130 and 136 GeV. The data sample corresponds to an integrated luminosity of 5 pb^{-1} collected during the high energy run of 1995. The shapes of the event shape distributions and the energy dependence of their mean values are well reproduced by QCD models. From a comparison of the data with resummed $\mathcal{O}(\alpha_s^2)$ QCD calculations, we determine the strong coupling constant to be $\alpha_s(133\ \mathrm{GeV}) = 0.107 \pm 0.005\ (\mathrm{exp}) \pm 0.006\ (\mathrm{theor})$.

Introduction

The theory of the strong interaction (QCD) has been quite successful in describing many aspects of jet structure found in hadronic final states produced in e^+e^- annihilation. Due to its nonabelian nature QCD predicts the strong coupling constant α_s to decrease with increasing energy. The 130-136 GeV e^+e^- annihilations produced at LEP at the end of 1995 have given a data set which is ideal to test QCD evolution predictions. We report on the studies of several event shape variables for these high energy hadronic final states.

Selection of Hadronic Events

For this analysis, we use events collected by the L3 detector[?] at center-of-mass energies of $\sqrt{s} = 130.3$ and 136.3 GeV corresponding to a total integrated luminosity of 5 pb^{-1}.

The event selection of $e^+e^- \to$ hadrons is based on the energy measured in the electromagnetic and hadronic calorimeters, appliyng standard cuts on cluster multiplicity and visible energy.

Thus we select about 1500 hadronic events. Applying the same cuts to fully simulated events we find that 96% of the hadronic events are accepted. The background due to two-photon collisions is estimated to be less than 4%.

To reduce the contamination of events with hard initial state radiation we apply two additional cuts:

- $(\mathrm{E_{vis}}/\sqrt{s}) > 2.5(|\ \mathrm{E_{\|}}\ |/\mathrm{E_{vis}}) + 0.5$
- energy of the most energetic $\gamma < 15$ GeV.

Thus the final sample used for this analysis contains 402 hadronic events.

Energy Dependences of the Mean Values

An important test of the QCD models is to check the predicted energy evolution of the shape distributions using the same Monte Carlo parameter values. The mean values of thrust and charged multiplicity are shown in Figure 1, together with measurements at the Z resonance [?,?] , as well as those at low energy e^+e^- machines. Also shown are the energy dependences of these quantities as predicted by JETSET 7.4 PS, HERWIG 5.6, ARIADNE 4.06, COJETS 6.23 and JETSET 7.4 ME Monte Carlo models with constant parameter values over the full energy range [?]. These models use different approach to describe the perturbative and non perturbative phase of QCD evolution. For the thrust distribution all the models agree above 90 GeV. They are also in good agreement with the present measurement at 130 and 136 GeV. For the charge multiplicity the situation is different. It should be noticed that the models have been tuned from global event shape distributions at 91 GeV without the use of particle multiplicity distributions [?]. The JETSET 7.4 ME model fails to describe the energy dependence of $< n_{ch} >$ over a wide energy range. This is understood as a consequence of a low parton multiplicity before fragmentation compared to the other models.

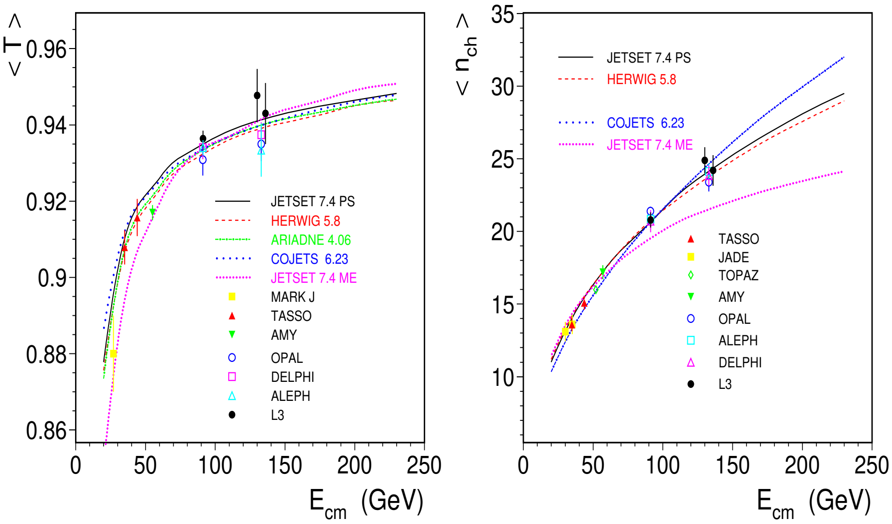

Figure 1:Distribution of mean thrust, $< T >$, and mean charge multiplicity, $< n_{ch} >$, as a function of the center-of-mass energy.

The measured mean values of thrust, scaled heavy jet mass, total jet broadening, wide jet broadening and charge multiplicity at 130 and 136 GeV are summarized in table 1.

Table 1: Mean values of thrust, T, scaled heavy jet mass, ρ, total jet broadening, B_T, wide jet broadening, B_W, and charge multiplicity, n_{ch}, measured at $\sqrt{s} = 130$ and 136 GeV. The first error is statistical and the second is systematic.

	$\sqrt{s} = 130$ GeV	$\sqrt{s} = 136$ GeV
$< T >$	0.948 ± 0.004 ± 0.007	0.943 ± 0.005 ± 0.008
$< \rho >$	0.045 ± 0.003 ± 0.001	0.046 ± 0.004 ± 0.001
$< B_T >$	0.095 ± 0.004 ± 0.001	0.094 ± 0.005 ± 0.001
$< B_W >$	0.067 ± 0.003 ± 0.001	0.066 ± 0.004 ± 0.001
$< n_{ch} >$	24.9 ± 0.5 ± 0.8	24.2 ± 0.7 ± 0.8

Results and Conclusions

In order to derive α_s, we fit the theoretical distribution for the thrust, the scaled heavy jet mass and jet broadening variables derived from the latest QCD calculations to the measured event shape distributions for a fixed scale $\mu = \sqrt{s}$.

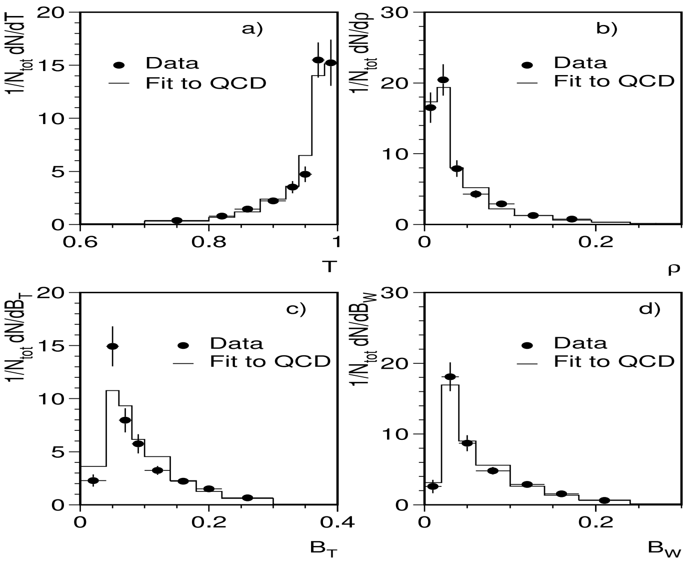

Figure 2:Measured distributions of thrust, T, scaled heavy jet mass, ρ, total, B_T, and wide, B_W, jet broadening in comparison with QCD predictions.The experimental errors include statistical and systematic uncertainties.

Figures 2(a-d) show the experimental data together with the QCD fits for the four variables thrust, scaled heavy jet mass, total and wide jet broadening. The results in table 2 are the α_s values as obtained from the fits to $\mathcal{O}(\alpha_s^2)$ + resummed calculations using hadronization corrections from JETSET with standard L3 parameters [?] together with the χ^2 values. The experimental and theoretical errors are also shown in table 2.

The systematic errors due to uncalculated higher order terms have been estimated independently from the scale uncertainty and the matching scheme uncertainty. The largest of these is taken as the theoretical uncertainty due to uncalculated higher orders. The overall theoretical error is obtained by adding to this in quadrature the hadronization uncertainty, found by using different hadronization models.

Table 2: α_s from the fits to the event shape variables

	$(1-T)$	ρ	B_T	B_W
α_s(133 GeV)	0.1094	0.1078	0.1071	0.1031
χ^2/d.o.f.	1.04	0.74	2.12	0.54
Overall experimental error	±0.0051	±0.0050	±0.0037	±0.0040
Overall theoretical error	±0.0072	±0.0031	±0.0079	±0.0057

The α_s values from the four distributions are affected differently by higher order corrections and hadronization effects. To obtain a combined value for the strong coupling constant we take the unweighted average of the four α_s values of table 2 and obtain $\alpha_s = 0.107 \pm 0.005\,(\mathrm{exp})$. We conservatively assign the overall theoretical uncertainty as the average of the four theoretical errors. The combined result is

$$\alpha_s(133\ \mathrm{GeV}) = 0.107 \pm 0.005 \pm 0.006$$

where the first error is experimental and the second error is theoretical.

References

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