Studies of QCD at Colliders

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1. Introduction

Experimental tests of QCD at colliders are frequently related to the energy scale dependence, i.e. the *running* of the strong coupling constant α_S. Combining the data of the OPAL and JADE experiments on event shapes at the e^+e^- colliders LEP and PETRA, respectively, covers the energy range from 12 to 209 GeV which allows for significant tests of the running. Similar investigations at the $p\overline{p}$ collider TeVatron consider the inclusive jet cross section.

2. QCD tests with JADE and OPAL data

Recent progress in QCD calculations promise a substantially improved precision in α_S determinations when re-analysing 15 year old JADE data taken at $\sqrt{s} = 12$ to 44 GeV. Enormous efforts to re-compile JADE data and to make ancient style programs running on new computers finally allowed for this unique measurement of α_S shown in Fig. 1 by applying the currently best QCD calculations, i.e. NLO matched with the resummed NLLA, to a large variety of event shape variables [1].

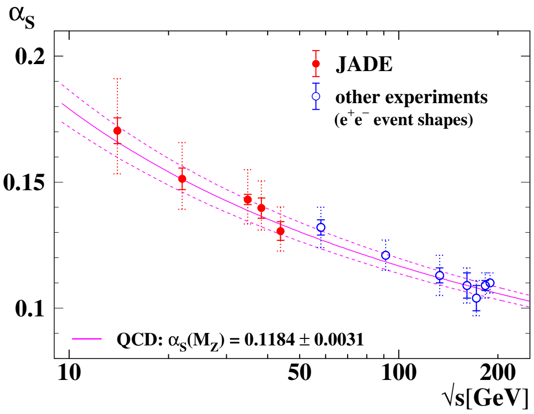

Fig. 1: $\alpha_S(\sqrt{s})$ from JADE data and other e^+e^- experiment.

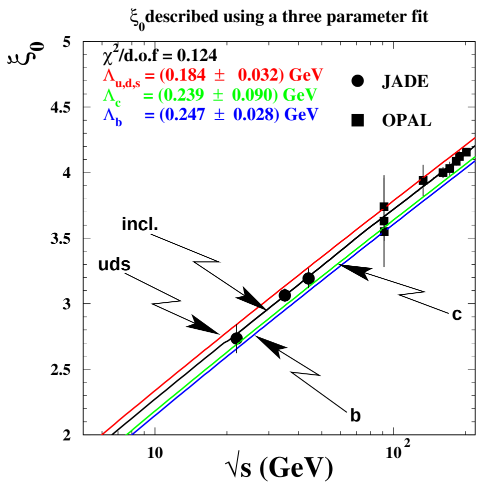

Fig. 2: Flavour dependent analysis of the $\sqrt{s}$ dependence of ξ_0.

The running of α_S can also be studied by the momentum distribution of the particles produced in one collision. In particular the NLLA calculation of QCD predicts a distorted gaussian shape for the $\xi \equiv \ln(1/x)$ distribution ($x = 2p/\sqrt{s}$). The peak position of this gaussian, ξ_0, moves with $\ln\sqrt{s}$ but decays of heavy bottom (and charm) quarks indeed affect ξ_0 due to an enhanced production of low momentum particles. This was found from the investigation of ξ distributions using JADE and OPAL data and exploiting the energy dependence of the production cross sections of bottom and charm quarks plus the direct measurement of ξ_0 for b, c, and the light (u, d, s) quarks by OPAL. Fig. 2 shows the result where Λ of the running coupling effectively absorbs the flavour dependence [2].

3. Jet algorithms for $p\overline{p}$ colliders

To reconstruct the direction and energy of partons from a hard interaction in $p\overline{p}$ collisions cone algorithms are frequently applied which consider all particles inside a cone of definite opening angle around the original parton as part of a particle jet from that parton. New algorithms were devised, e.g. Midpoint cone, since some old cone algorithms suffer from theoretical and experimental deficiencies [3]. In Fig. 3 the performance of the Midpoint algorithm is compared with that of the KtClus algorithm which does not rely on cones to find the jets. The comparison considers two partons in the plane spanned by pseudo-rapidity, η, and azimuthal angle φ. The two partons at a distance $d \equiv \sqrt{(\Delta\eta)^2 + (\Delta\varphi)^2}$ are represented by gaussians with $\sigma = 0.25$ and ratio z in height, i.e. the transverse energy E_T. The vertical lines in Fig. 3 separate the regions where one (two) stable cones/jets might be found by the algorithms in the case $\sigma = 0$. Midpoint might even find three stable cones in the region between the vertical and the diagonal line in Fig. 3(a). It should be observed that Midpoint tends to merge the two partons even when they are well separated if their E_T ratio z is small.

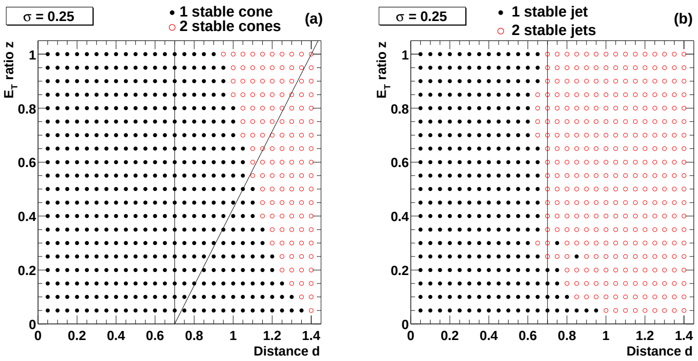

Fig. 3: Performance of (a) Midpoint cone and (b) KtClust algorithm to resolve two jets with distance d in $\eta - \varphi$ and ratio z of transverse energy E_T

References

[1] P.A. Movilla Fernández: `http://arXiv.org/abs/hep-ex/0205014`
[2] M. Blumenstengel: `http://arXiv.org/abs/hep-ex/0212015`
[3] S.D. Ellis, J. Huston, M. Tönnesmann: `http://arXiv.org/abs/hep-ph/0111434`