π^0, η, K^0 and Charged Particle Multiplicities in Quark and Gluon Jets

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We compare the charged particles, the π^0, the η and the K^0 mean multiplicities in quark and gluon jets in 3-jet events, as measured by the OPAL experiment at LEP [1]. The comparison is performed for distributions unfolded to 100% pure quark and gluon jets, at an effective scale Q that takes into account topology dependences [2] in the 3-jet environment. The measured average charged particle multiplicity for quark jet $N_{ch}^{quark}(Q)$ and gluon jet $N_{ch}^{gluon}(Q)$ are shown on fig. 1-a. They are fitted simultaneously to a QCD-inspired formula as a function of log(Q). The obtained formula, with all parameters fixed but scaled with a single normalisation factor, has been found to describe reasonably well the corresponding measured spectra of the π^0, η and K^0 mesons. As a consequence, the mean multiplicity ratio $R(Q) = \frac{<N_s^{gluon}>}{<N_s^{quark}>}(Q)$ is fairly independent of the studied particle species: s = { inclusive charged particles, π^0, η or K^0}. This is a confirmation of the QCD prediction that the enhancement of the mean particle rate in gluon jets over quark jets should be irrespective of the particle type.

XFrom a QCD perturbative calculation, the ratio of the gluon and quark multiplicities has to converge to a constant at large Q. This constant is an estimate of the QCD color factor ratio $R = C_A/C_F = 9/4$. This also implies [3] that the ratio of the slopes $\frac{<dN_s^g>/dQ}{<dN_s^q>/dQ}(Q)$ of quark and gluon multiplicities should converge to the same constant. The measured ratio of the slopes is shown on fig. 1-c and it is fitted to a constant $C = 2.29 \pm 0.08$ consistent with the QCD value of R.

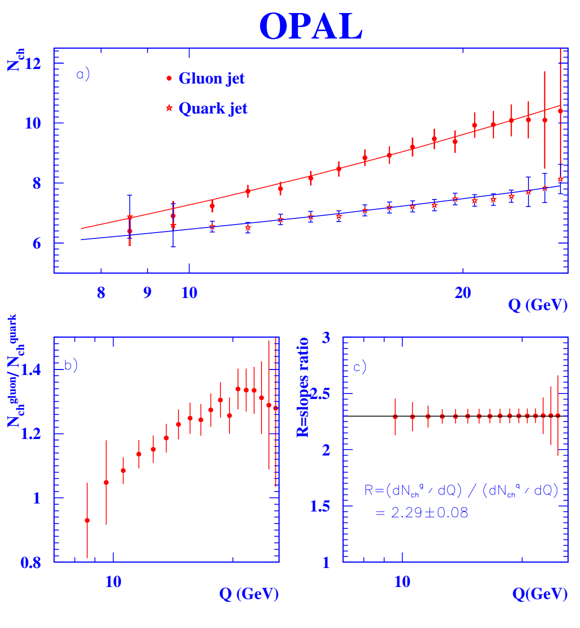

Fig. 1: a) Average number of charged particles for pure gluon and quark jets as a function of the scale Q. The continuous curves are from the fit to the QCD inspired analytical formula. b) Ratio gluon/quark of the average charged multiplicity as a function of the scale Q. c) The slope ratio

The inclusive differential rate, as a function of the beam momentum fraction x_E carried by the meson, have been measured and are shown on fig. 2 for π^0, η and K^0 using the full available sample of Z^0hadronic decays. The η and K^0 spectra are found to be harder than the OPAL-tuned Monte Carlo prediction.

The total measured inclusive rates of π^0, η and K^0 agree with the measured LEP average values. While the Monte Carlo predicted total inclusive rate of π^0 and K^0 are found to agree with the measured one, the measured total inclusive rate for η was found to be larger than the predicted rate. The enhancement is mainly in the region of high x_E and it is is also present in the selected 3-jet event sample. This observation is in agreement with a former measurement [4] that reported in addition that the enhancement is caused by the gluon enriched jet sample. This last result suggests that, in addition to the QCD predicted enhancement in gluon jets with respect to quark jets at equal jet energies, other η meson sources in gluon jets might exist. A general enhancement of isoscalar mesons and glueballs in gluon jets with respect to quark jets is theoretically predicted [5]. However, in the present analysis, were rates have been measured as a function of the jet scale Q unfolded to 100% quark and gluon jet purities, the excess in data cannot be attributed exclusively to an enrichment in gluon jets. It is present in relative equal amounts in both quark and gluon jets.

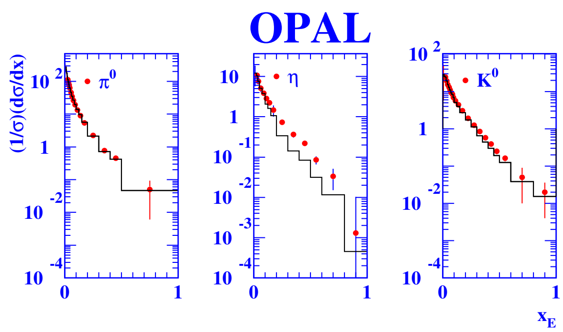

Fig. 2: Differential production rates for π^0, η , and K^0 mesons in Z^0 decays. Histograms are the JETSET expected rates.

References

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