

on as individual quanta until they have either radiated off further energy, or recombine with a less-energetic partner. Consequently, the cluster size distribution is shifted to larger radii, not however very significantly, because only a small fraction (typically less than 5 %) of the clusters are affected. At the same time, the mass distribution loses its high-mass tail and falls off considerably above 3 GeV, and the average cluster mass comes down substantially to $\langle M_{cl} \rangle \simeq 0.8$ GeV.

The most remarkable result of Figs. 10 and 11, however, is that the shapes of both the cluster size and cluster mass distribution are essentially independent of the jet energy, as well as of the initial 2-jet configuration, and therefore appear to be universal.

The decay of the spectrum of formed clusters into hadrons, simulated according to the Sec. 4.5, then yields the average particle multiplicities of final-state hadrons. It is interesting to look at the relation between parton and hadron multiplicities. The feature evident in Figs 10b and 11b, namely that the mass spectrum of color-singlet clusters is independent of the total jet energy, is in agreement with analytical predictions [31]. This implies that parton and hadron multiplicities should be proportional to each other at high energies, which is known as *local parton-hadron duality* [32]. Fig. 12 display our results for the total gluon and quark multiplicities $\langle n_{qg} \rangle = \langle n_g \rangle + \sum_f \langle n_q + n_{\bar{q}} \rangle$, as well as the ratios of charged hadrons to partons $\langle n_{ch} \rangle / \langle n_{qg} \rangle$, and of clusters to partons, $\langle n_{cl} \rangle / \langle n_{qg} \rangle$, as a function of jet energy Q . In Fig. 12a the calculated rise of $\langle n_{qg} \rangle$ is shown for the two choices of L_c . The smaller value of L_c gives a larger multiplicity because we identified L_c^{-1} with the scale Λ_{QCD} in α_s , eq. (54). From Fig. 12b one reads off, however, that the average number of clusters per parton is independent of L_c and of energy Q . As a consequence, the number of charged hadrons per parton is larger for larger L_c , because at any fixed Q and due to 4-momentum conservation, fewer partons yield more massive clusters which in turn decay in a larger number of low-mass hadrons. Most important, one sees that the ratio $\langle n_{ch} \rangle / \langle n_{qg} \rangle$ is only weakly energy-dependent for $Q \gtrsim 30$ GeV, in accord with the hypothesis of local parton-hadron duality: it rises over this range by less than 10% and appears to saturate asymptotically, approaching a constant of ≈ 1.6 (1.7) for $L_c = 0.6$ (0.8) fm .

The resulting average multiplicity of charged hadrons as it rises with Q is shown in Fig. 13a together with experimental data [45, 46]. In order to obtain the correct overall normalization, we fitted the the infrared regulator k_0 entering α_s , eq. (54), to give the