We assign a theoretical error equal to 1/2 of the contribution from the order α^3 and nonperturbative contributions. This then gives $\alpha_s(m_\tau) = 0.360 \pm 0.041$ for the final result. Note that the experimental errors are dominant. The small theoretical errors have been criticized [33].

25.5. QCD in high-energy hadron collisions

There are many ways in which perturbative QCD can be tested in high-energy hadron colliders. The quantitative tests are only useful if the process in question has been calculated beyond leading order in QCD perturbation theory. The production of hadrons with large transverse momentum in hadron-hadron collisions provides a direct probe of the scattering of quarks and gluons: $qq \to qq$, $qg \to qg$, $gg \to gg$, *etc.* The present generation of $p\overline{p}$ colliders provide center-of-mass energies which are sufficiently high that these processes can be unambiguously identified in two-jet production at large transverse momentum. Recent higher–order QCD calculations of the jet rates [34] and shapes are in impressive agreement with data [35].

QCD corrections to Drell-Yan type cross sections (*i.e.*, the production in hadron collisions by quark-antiquark annihilation of lepton pairs of invariant mass Q from virtual photons, or of real W or Z bosons) are known [38]. These $\mathcal{O}(\alpha_s)$ QCD corrections are sizable at small values of Q.

It is interesting to note that the corresponding correction to W and Z production, as measured in $p\overline{p}$ collisions at $\sqrt{s} = 0.63$ TeV and $\sqrt{s} = 1.8$ TeV has essentially the same theoretical form and is of order 30%.

The production of W and Z bosons and photons at large transverse momentum can also be used to determine α_s. The leading-order QCD subprocesses are $q\overline{q} \to \gamma g$ and $qg \to \gamma q$. If the parton distributions are taken from other processes and a value of $\Lambda^{(4)}_{\overline{\rm MS}}$ assumed, then an absolute prediction is obtained. Conversely, the data can be used to extract information on quark and gluon distributions and on the value of $\Lambda^{(4)}_{\overline{\rm MS}}$. The next-to-leading-order QCD corrections corrections are known [39,40] (for photons) and for W/Z production [41], and so a precision test is possible in principle. The UA2 collaboration [42] has extracted a value of $\alpha_s(M_W) = 0.123 \pm 0.018(\text{stat.}) \pm 0.017(\text{syst.})$ from the measured ratio $R_W = \dfrac{\sigma(W + 1jet)}{\sigma(W + 0jet)}$.

25.6. QCD in heavy quarkonium decay

Under the assumption that the hadronic and leptonic decay widths of heavy $Q\overline{Q}$ resonances can be factorized into a nonperturbative part—dependent on the confining potential—and a calculable perturbative part, the ratios of partial decay widths allow measurements of