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Improved strong coupling determinations from hadronic decays of electroweak bosons at N^{3}LO accuracy

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We present two new extractions of the QCD coupling constant at the Z pole, $\alpha_S(m_Z)$, from detailed comparisons of inclusive W and Z hadronic decays data to state-of-the-art perturbative Quantum Chromodynamics calculations at next-to-next-to-next-to-leading order (N^{3}LO) accuracy, incorporating the latest experimental and theoretical developments. In the W boson case, the total width computed at N^{3}LO is used for the first time in the extraction. For the Z boson pseudo-observables, the N^{3}LO results are complemented with the full two- and partial three-loop electroweak corrections recently made available, and the experimental values are updated to account for newly estimated LEP luminosity biases. A combined reanalysis of the Z boson data yields $\alpha_S(m_Z) = 0.1203 \pm 0.0028$, with a 2.3\% uncertainty reduced by about 7\% compared to the previous state-of-the-art. From the combined W boson data, a value of $\alpha_S(m_Z) = 0.101 \pm 0.027$ is extracted, with still large experimental uncertainties but also reduced compared to previous works. The levels of theoretical and parametric precision required in the context of QCD coupling determinations with permil uncertainties from high-statistics W a nd Z boson samples expected at future e^+e^- colliders such as the FCC-ee, are discussed in detail.

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