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Abstract

An update of measurements of the strong coupling α_s and the determination of the world average value of $\alpha_s(M_Z^2)$ is presented, resulting in

$$\alpha_s(M_Z^2) = 0.1181 \pm 0.0011.$$

Keywords: strong coupling, alpha-s, Quantum Chromodynamics

Several new measurements of α_s, the coupling strength of the strong interaction between quarks and gluons, became available since previous summaries were given at this conference series [1] and in the 2014 Review of Particle Properties [2]. In the following, those new results which are used to determine the new world average value of α_s, i.e. those that are based on at least complete next-to-next-to-leading order (*NNLO*) perturbation theory, are published in peer-reviewed journals and contain complete estimates of experimental and systematic uncertainties, will be summarised. Also results which are used for demonstrating asymptotic freedom, i.e. the specific energy dependence of α_s as predicted by Quantum Chromodynamics, even if being based on next-to-leading (*NLO*) perturbation theory only, will be reviewed.

This update with status of April 2016 is extracted from the most recent version of the Review of Particle Properties [3]; see this reference and [2] for a complete list of references, and for a detailed presentation of theoretical and experimental issues concerning tests of Quantum Chromodynamics.

The newest and most actual entries satisfying the quality criteria given above are:

- updated results from τ-decays [4] [5] [6], based on a re-analysis of ALEPH data and on complete N^3LO perturbation theory,
- more results from unquenched lattice calculations, [7][8],
- further results from world data on structure functions, in *NNLO* QCD [9],
- from e^+e^- hadronic event shapes (C-parameter) in soft collinear effective field theory matched to *NNLO* perturbation theory [10],
- α_s determinations at LHC, from data on the ratio of inclusive 3-jet to 2-jet cross sections [11], from inclusive jet production [12], from the 3-jet differential cross section [13], and from energy-correlations [14], all in *NLO* QCD, plus one determination in complete *NNLO*, from a measurement of the $t\bar{t}$ cross section at $\sqrt{s} = 7$ TeV [15];
- and finally, an update of α_s from a global fit to electroweak precision data [16], based on complete N^3LO perturbation theory.

All measurements based on at least full *NNLO* perturbation theory are summarised in figure 1, and are ordered according to subclasses of τ-decays, lattice results, structure functions, e^+e^--annihilation, electroweak precision fits and hadron colliders.

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With the exception of lattice results, most results within their subclass are strongly correlated, however to an unknown degree, as they largely use similar data sets and/or theoretical predictions. The large scatter between many of these measurements, sometimes with only marginal or no agreement within the given errors, indicate the presence of additional systematic uncertainties from theory or caused by details of the analyses. Therefor the unweighted average of all selected results is taken as pre-average value for each subclass, and the unweighted average of the quoted uncertainties is assigned to be the respective overall error of this pre-average.

For the subclasses of hadron collider results and electroweak precision fits, only one result each is available in full *NNLO*, so that these measurements alone define the average value for their subclass. Note that more measurements of top-quark pair production at LHC are meanwhile available, indicating that - on average - a larger value of $\alpha_s(M_Z^2)$ is likely to emerge in the future; see also [17] and the presentation of T. Klijnsma at this conference [18]. The resulting subclass averages are indicated in figure 1, and are summarized in table 1.

Table 1: Pre-average values of subclasses of measurements of $\alpha_s(M_Z^2)$.

Subclass	$\alpha_s(M_Z^2)$
τ-decays	0.1192 ± 0.0018
lattice QCD	0.1188 ± 0.0011
structure functions	0.1156 ± 0.0021
e^+e^- [jets & shps]	0.1169 ± 0.0034
hadron collider	$0.1151\ ^{+\,0.0028}_{-\,0.0027}$
ew precision fits	0.1196 ± 0.0030

Assuming that the resulting pre-averages are largely independent of each other, the final world average value is determined as the weighted average of the pre-averaged values. An initial uncertainty of the central value is calculated treating the uncertainties of all input values as being uncorrelated and of Gaussian nature, and the overall χ^2 to the central value is determined. If the initial χ^2 is smaller than the number of degrees of freedom, an overall, a-priori unknown correlation coefficient is introduced and adjusted such that the total χ^2/d.o.f. equals unity. Applying this procedure to the values listed in table 1 results in the new world average of

$$\alpha_s(M_Z^2) = 0.1181 \pm 0.0011 \ .$$

This value is in good agreement with that from

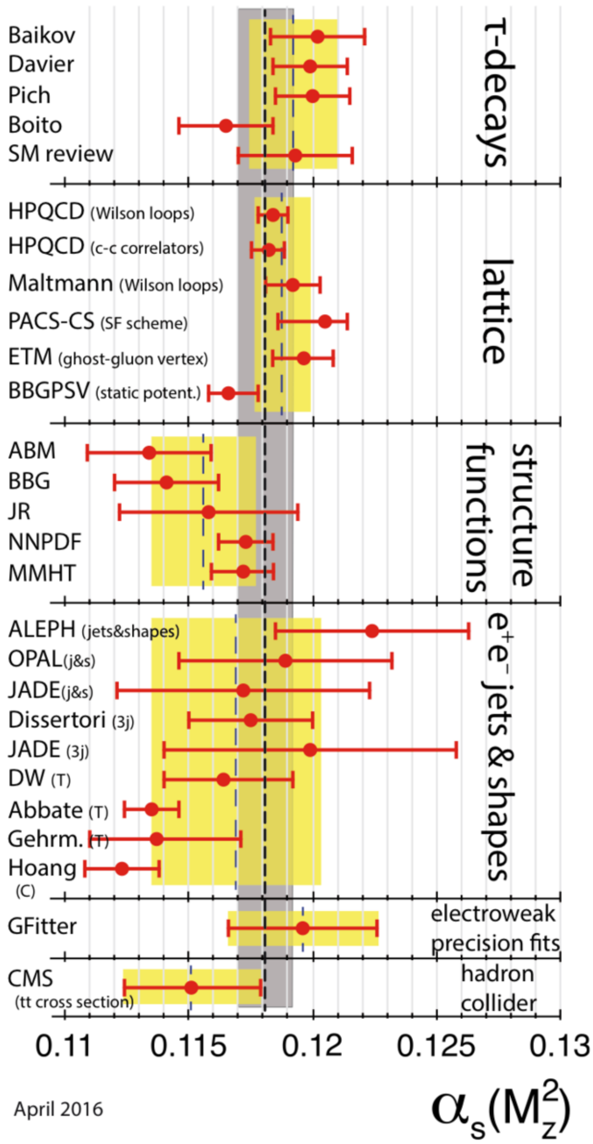

Figure 1: Summary of determinations of α_s. The light-shaded bands and long-dashed vertical lines indicate the pre-average values as explained in the text and as listed in table 1; the dark-shaded band and short-dashed line represent the new overall world average of α_s.