World summary

of

α_s (2011)

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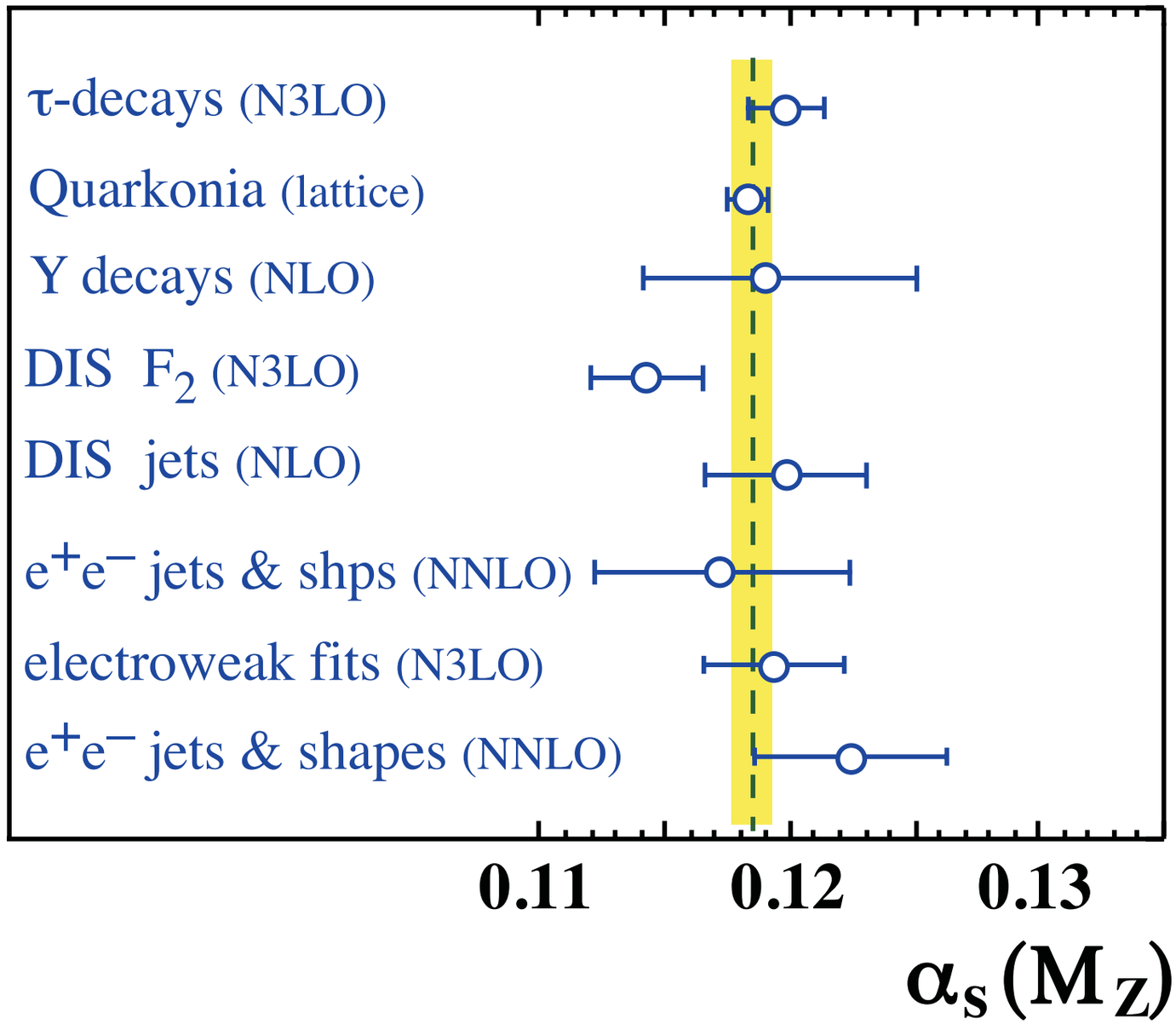
World Summary of α_s 2009:



(Bethke, arXiv:0908.1135)

$\rightarrow\ \alpha_s(M_Z) = 0.1184 \pm 0.0007$

n.b.:
- entirely new set of input data !
- 2006 result was: $\alpha_s(M_Z) = 0.1189 \pm 0.0010$

measurements included in 2009 summary :

- N3LO ($O(\alpha_s^4)$) correction for τ-decays and width of Z^0 boson (Baikov, Chetyrkin, Kühn; arXiv:0801.1821)

- improved results from unquenched lattice calculations (C.T.H. Davies et al.; arXiv:0807.1687)

- results from heavy quarkonia decays (NLO)
  (N. Brambilla et al., hep-ph/0702079)

- α_s from world data of non-singlet structure functions (up to N3LO in some parts)
  (J. Blümlein et al., hep-ph/0607200)

- combination of jet data from HERA experiments (NLO)
  (C. Glasmann et al., arXiv:0709.4426)

- NNLO ($O(\alpha_s^3)$) corrections for $e^+ e^-$ hadronic event shapes and jet rates —> reanalysis of LEP and of PETRA (JADE) data.

  (Dissertori, Gehrmann et al., arXiv:0806.4601; S. Bethke et al., arXiv:0810.1389)

new measurements added in 2011 summary :

- once more: results from τ-decays and electroweak precision data (in N3LO)

  (A. Pich; arXiv:1107.1123; M. Baak et al. (GFITTER), arXiv:1107.0975)

- more results from unquenched lattice calculations

  (C.T.H. Davies et al., arXiv:1004.4285; K. Maltmann, arXiv:0807.2020; S. Aoki et al., arXiv:1002.0371;
  E. Shintani et al., arXiv:0906.3906)

- more α_s from world data of structure functions (in NNLO)

  (S. Alekhin et al., arXiv:1101.5261; P. Jimenez-Delgado, E. Reva, arXiv:0810.4274; A.D. Martin et al., arXiv:0905.3531)

- α_s from hadron collider incl. jet production (in NLO)

  (M. Abazov et al., D0 collab., arXiv:0911.2710)

- more results from $e^+ e^-$ hadronic event shapes and jet rates (resummed NNLO)

  (OPAL collab., G. Abbiendi et al., arXiv:1101.1470; G. Dissertori et al., arXiv:0910.4283)

  5-jet rates (NLO) (R. Frederix et al., arXiv:1008.5313)

  T-distrib. in soft collinear effective field theory (incl. NNLO) (R. Abbate et al., arXiv:1006.3080)

problems encountered in 2011 summary :

- different determinations of α_s from substantially similar datasets ....
- .... which sometimes are only marginally compatible with each other ....
- .... and/or with the resulting world average

——> *presumably underestimated systematic uncertainties*

therefore :

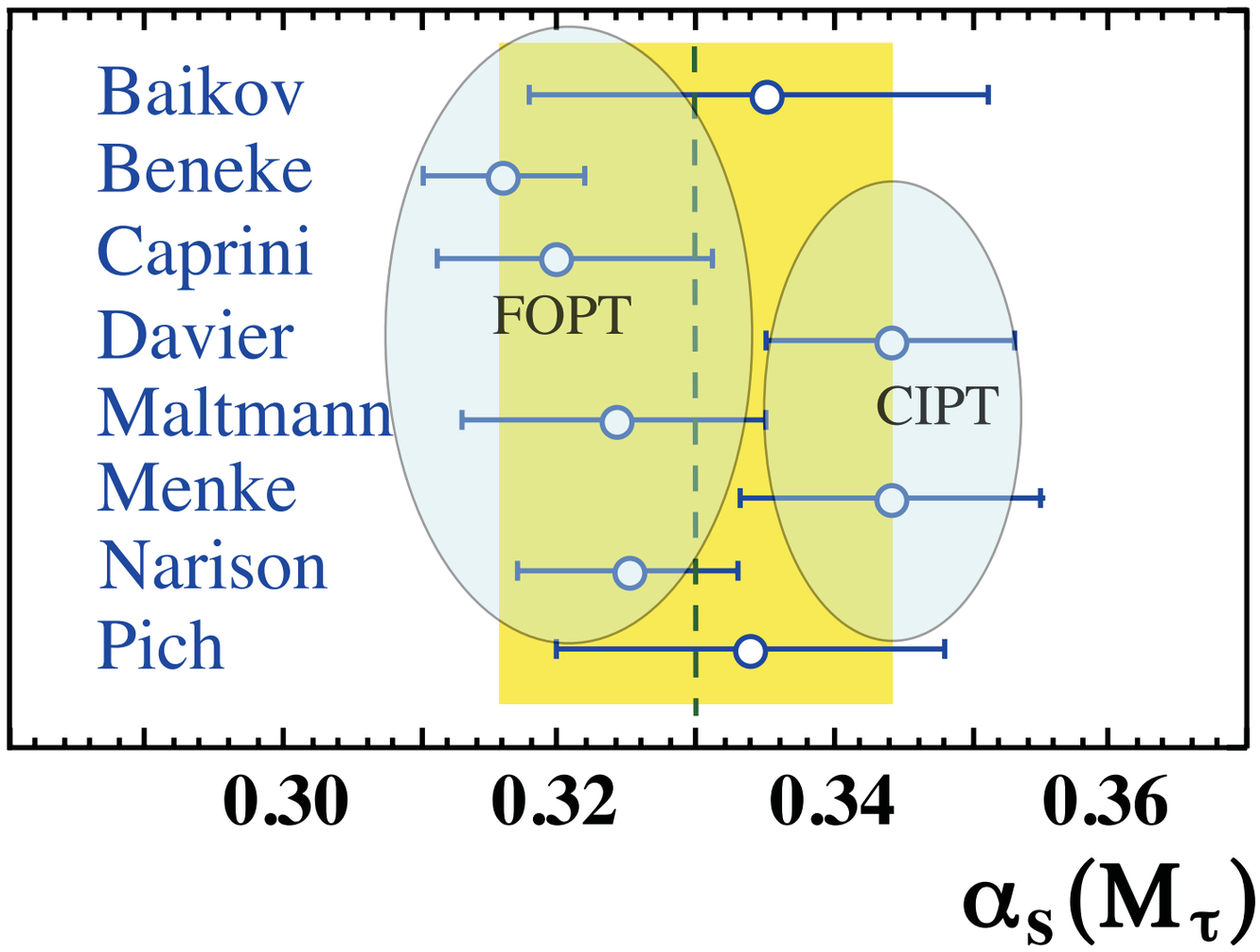
- determination of pre-averages of α_s within sub-classes (τ-decays, lattice, DIS, e^+e^- annihilation); pre-averages are then combined into world-average
- pre-average of results from similar datasets: encompass individual central values
- pre-average of results from different datasets: weighted average enforcing χ^2 /dof = 1

and another difference to 2009 summary :

- restriction to include only results based on complete NNLO at least!

α_s from τ-decays

- complete N3LO prediction (Baikov, Chetyrkin, Kühn; arXiv:0801.1821)
- strong theor. activities
- large dependence on details of perturbative expansion:
  FOPT vs. CIPT; some dependence on nonpert. corrections



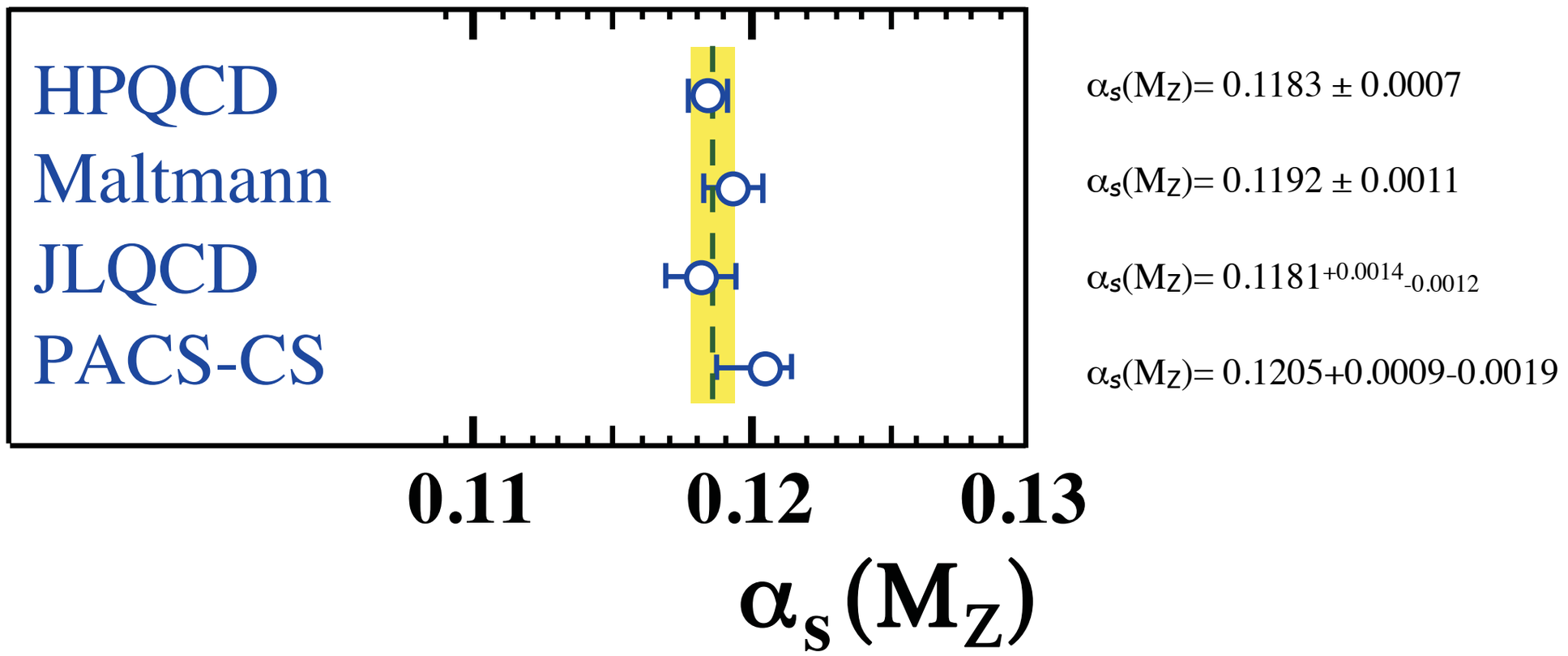
- averaging and summarising: $\alpha_s(M_\tau) = 0.330 \pm 0.014$

  $\rightarrow$ $\alpha_s(M_Z) = 0.1197 \pm 0.0016$

α_s from lattice QCD

- compute short-distance quantities with lattice QCD (Wilson loops, Adler functions, ...); analyse them with NNLO perturbative QCD

- increasingly inclusive and precise (incl. vacuum polarisation of u, d, s quarks; finer lattice spacing, ...)



$\alpha_s(M_Z)= 0.1183 \pm 0.0007$

$\alpha_s(M_Z)= 0.1192 \pm 0.0011$

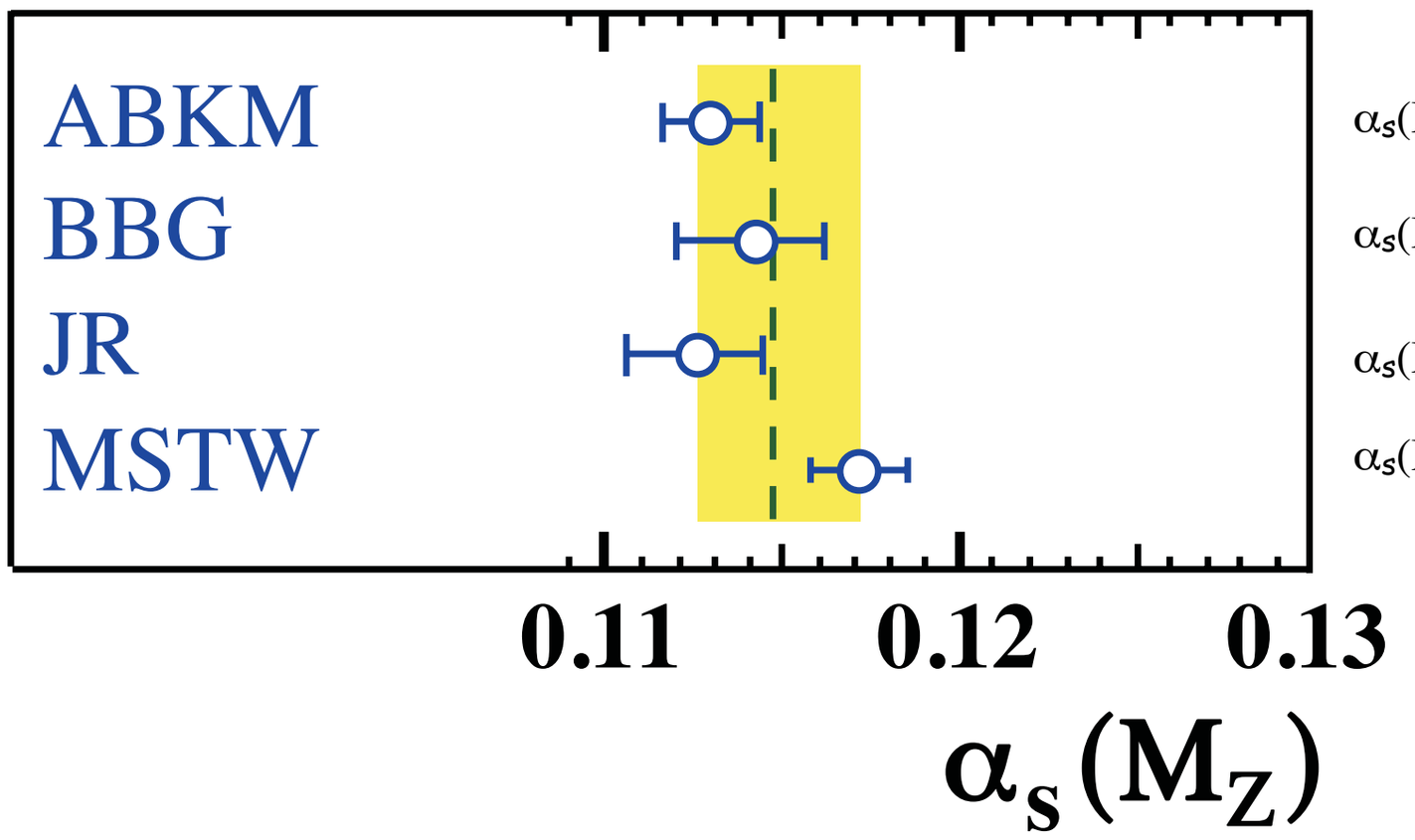
$\alpha_s(M_Z)= 0.1181^{+0.0014}_{-0.0012}$

$\alpha_s(M_Z)= 0.1205+0.0009-0.0019$

$\rightarrow$ $\alpha_s(M_Z)= 0.1186 \pm 0.0008$

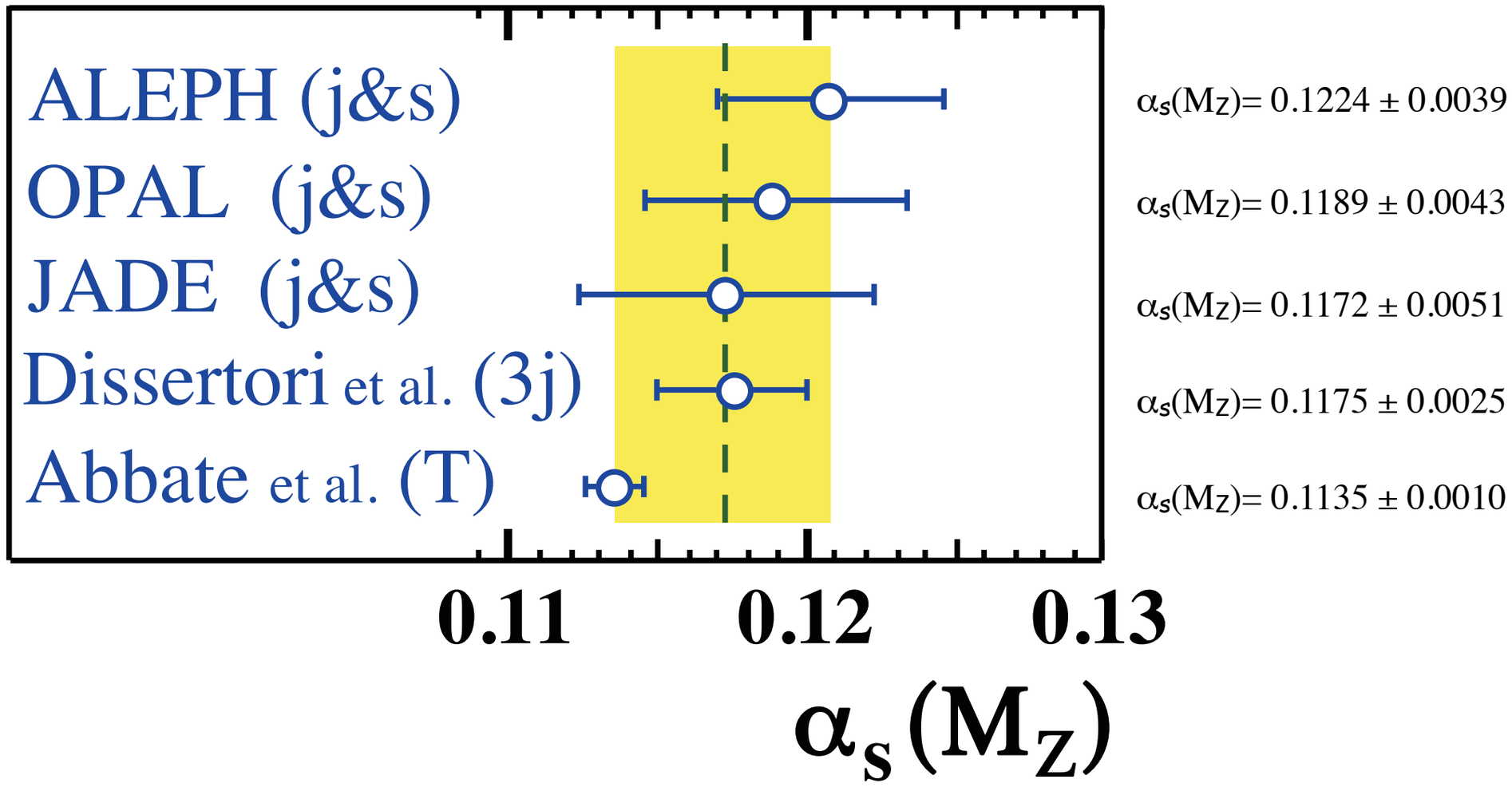
α_s from DIS structure functions

- determination of parton densities from DIS; QCD in NNLO (up to N3LO);
- MSTW: include hadron collider jet data (in order to constrain gluon at large x)



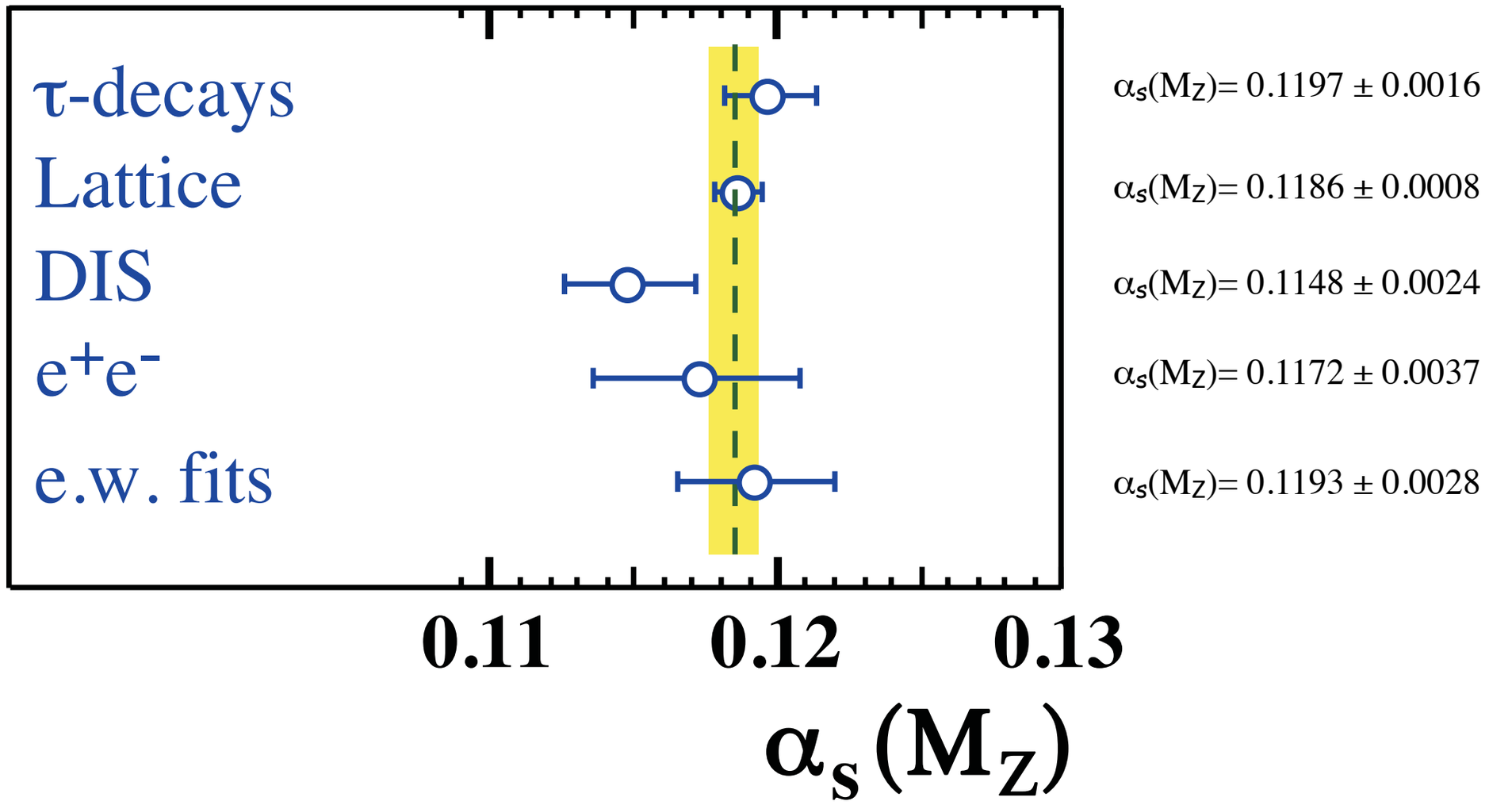
–> $\alpha_s(M_Z)$= 0.1148 ± 0.0024

α_s from jets and event shapes in e^+e^- annihilation



-> $\alpha_s(M_Z)= 0.1172 \pm 0.0037$

World Summary of α_s 2011:



-> $\alpha_s(M_Z)= 0.1185 \pm 0.0008$

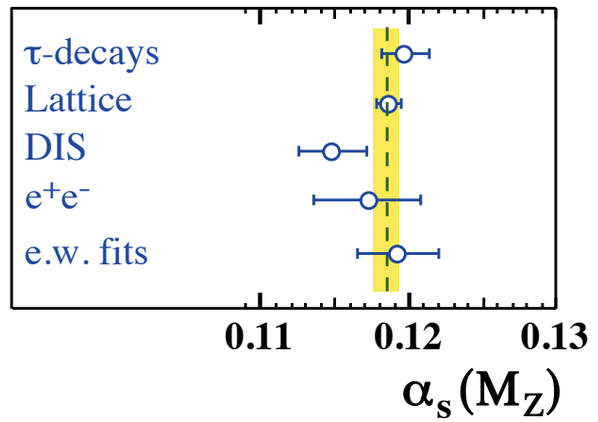
(-> RPP 2012)

$\Lambda_{\overline{MS}}^{(5)} = (214 \pm 10)$ MeV

$\Lambda_{\overline{MS}}^{(4)} = (298 \pm 12)$ MeV

World Summary of α_s 2011:

$\alpha_s(M_Z) = 0.1185 \pm 0.0008$



Process	$\alpha_s(M_{Z^0})$	excl. mean $\alpha_s(M_{Z^0})$	std. dev.
τ-decays	0.1197 ± 0.0016	0.1183 ± 0.0008	0.8
Lattice QCD	0.1186 ± 0.0008	0.1183 ± 0.0011	0.2
DIS $[F_2]$	0.1148 ± 0.0024	0.1188 ± 0.0011	1.5
e^+e^- [jets & shps]	0.1172 ± 0.0037	0.1185 ± 0.0007	0.3
ew. prec. data]	0.1193 ± 0.0028	0.1184 ± 0.0007	0.3

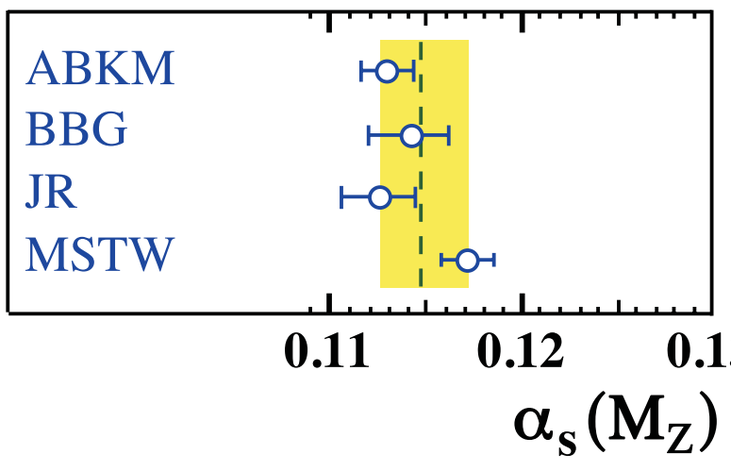
- most precise single result: from lattice QCD
- exclusive average values scatter only mildly (0.1183 ... 0.1188)
- lattice results coincides with exclusive average (w/o lattice), but largely influences overall error
- very consistent scatter of single results around overall average
- systematic unknowns in DIS / F_2 results ?

World Summary of α_s 2011:

$\alpha_s(M_Z) = 0.1185 \pm 0.0008$

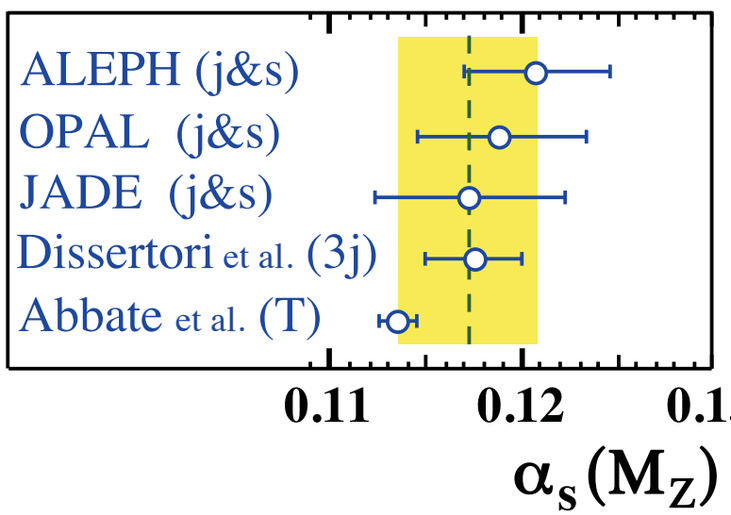
further systematic studies: leave out *single* results

- leave out MSTW: DIS —> $\alpha_s(M_Z)_{DIS} = 0.1130 \pm 0.0015$

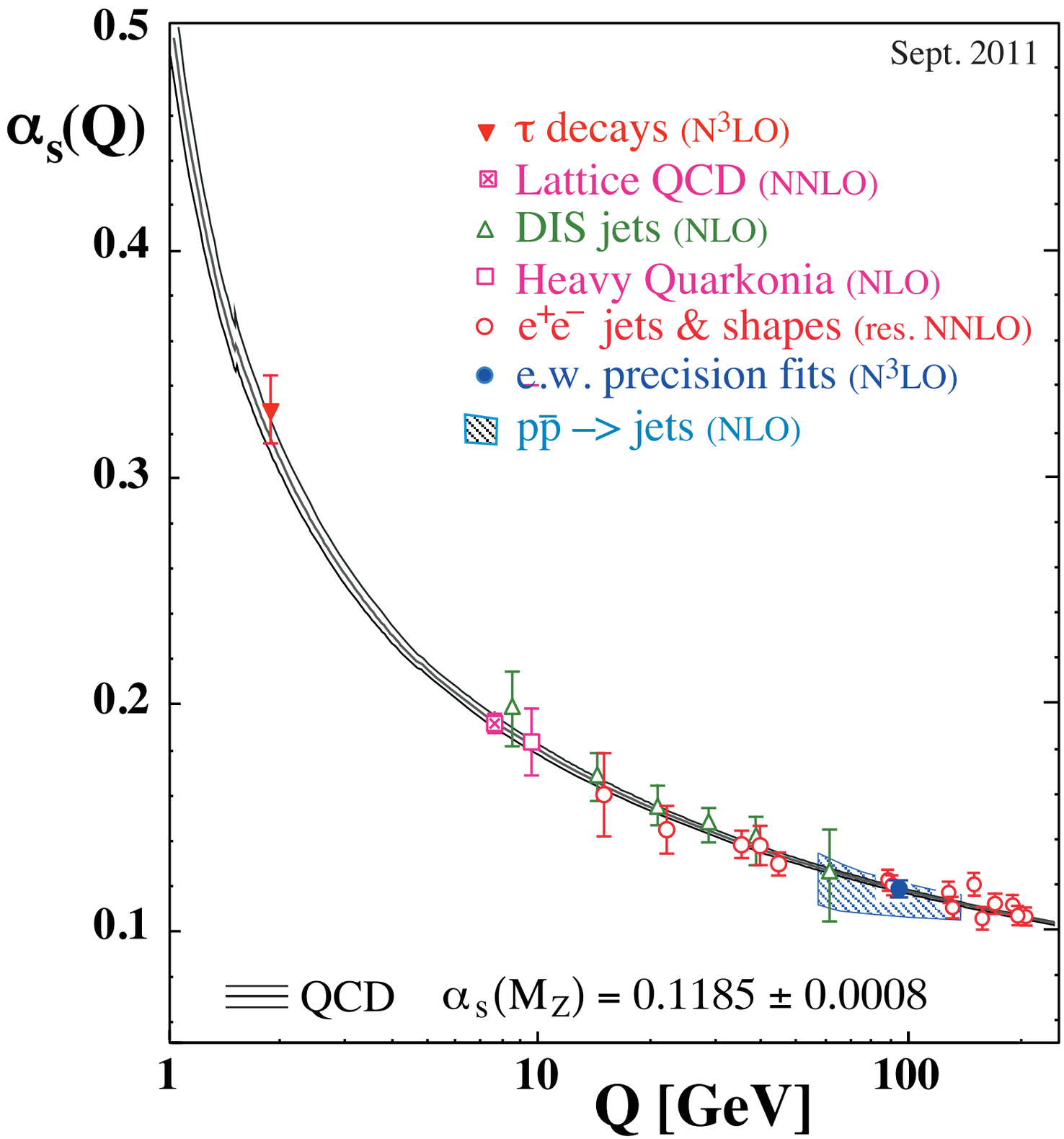


w.a. $\alpha_s(M_Z) = 0.1178 \pm 0.0011$

- leave out Abbate: e+e- —> $\alpha_s(M_Z)_{e+e-} = 0.1190 \pm 0.0040$



w.a. $\alpha_s(M_Z) = 0.1186 \pm 0.0008$


Sept. 2011
$\alpha_s(Q)$
0.5
0.4
0.3
0.2
0.1
τ decays (N³LO)
Lattice QCD (NNLO)
DIS jets (NLO)
Heavy Quarkonia (NLO)
e⁺e⁻ jets & shapes (res. NNLO)
e.w. precision fits (N³LO)
pp̄ –> jets (NLO)
QCD $\alpha_s(M_Z) = 0.1185 \pm 0.0008$
1
10
100
Q [GeV]

evidence for asymptotic freedom: