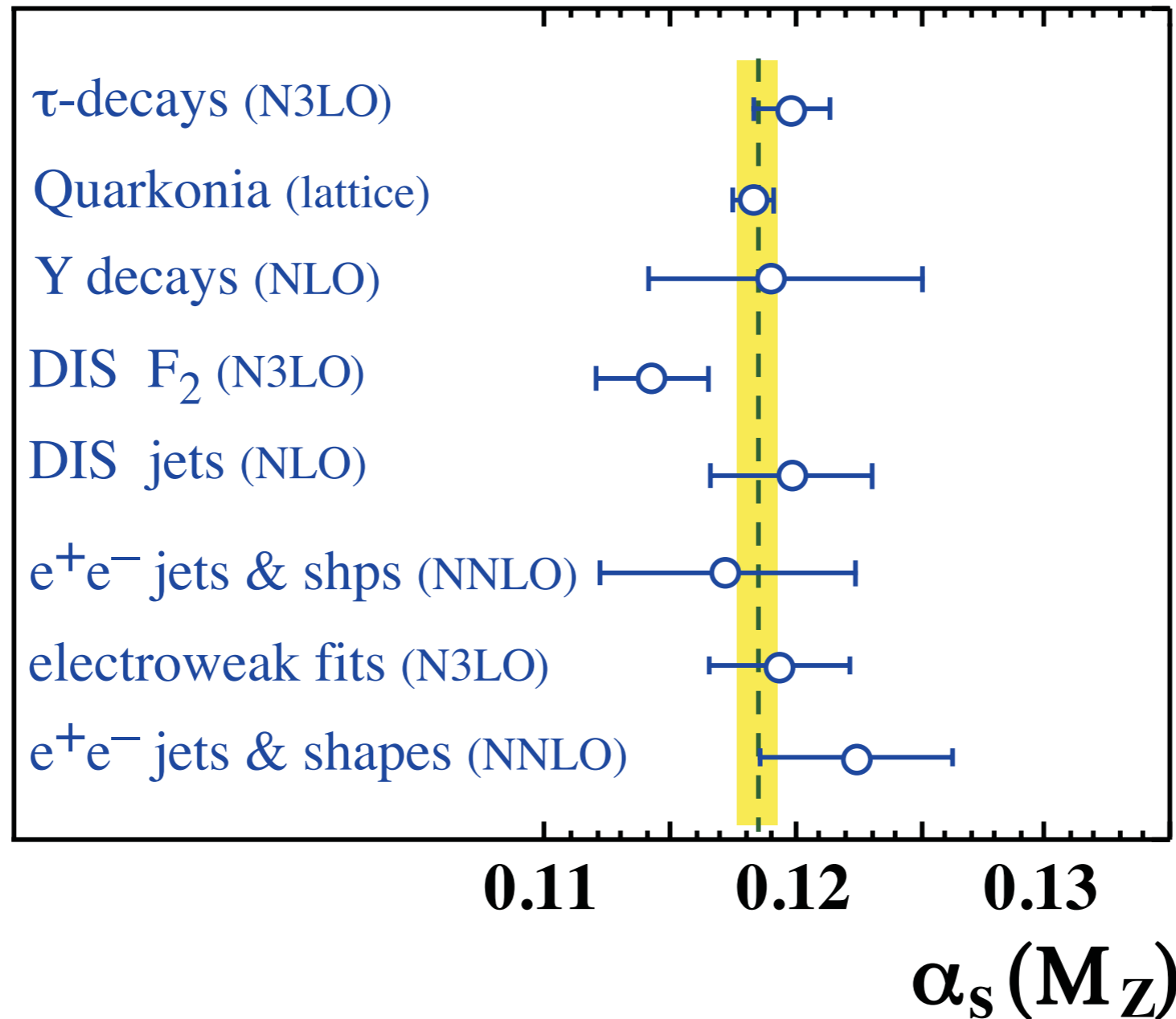


World summary of α_s (2012)

S. Bethke
MPI für Physik, Munich

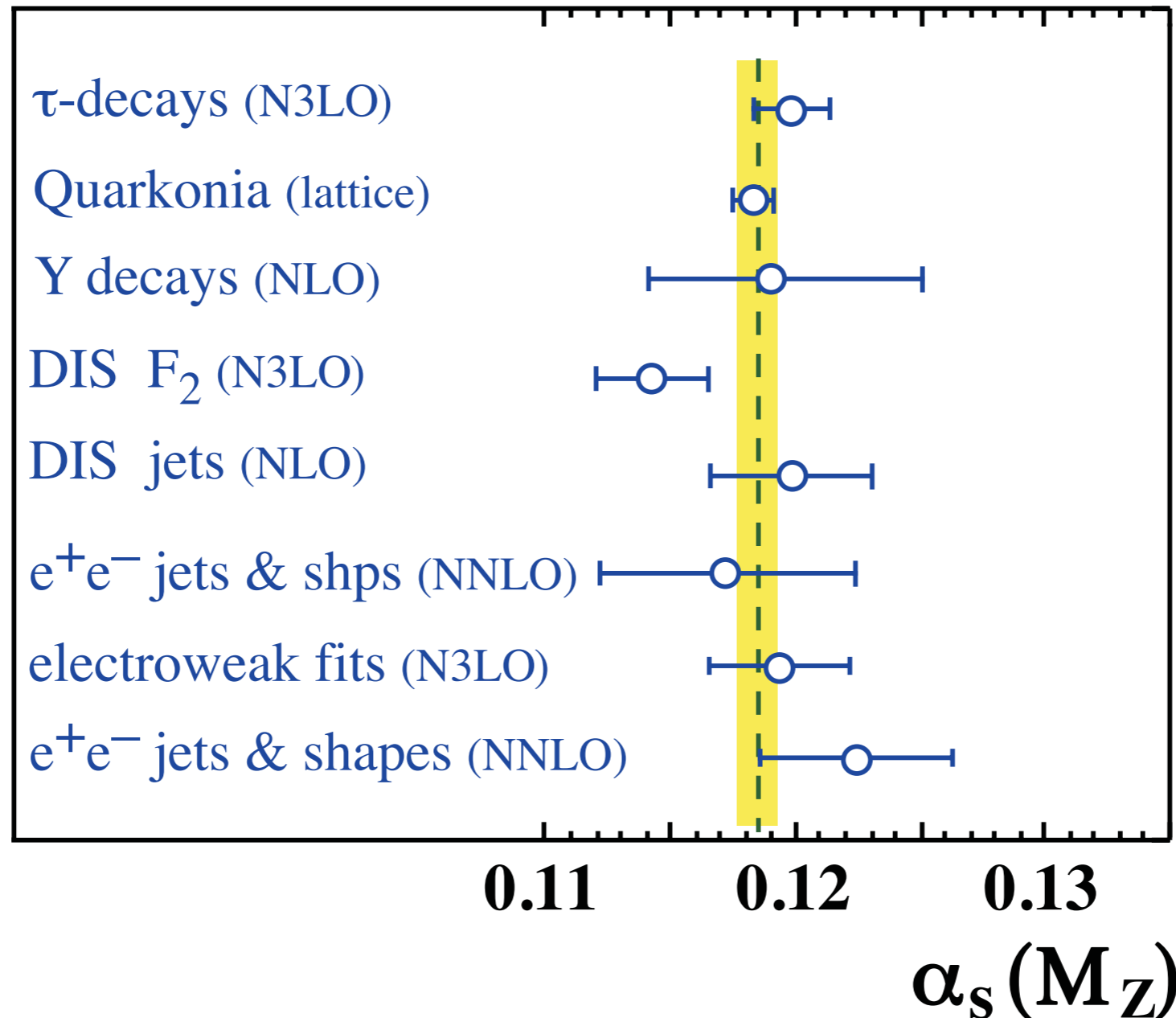
World Summary of α_s 2009:



(arXiv:0908.1135)

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

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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 \longrightarrow reanalyses 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 2011/2012 summary :

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

(D. Boito et al.; arXiv:11115040; arXiv:1203.3146;
M. Baak et al. (GFITTER), arXiv:1107.0975; P. Baikov et al., arXiv:1201.5804)

- 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)
D. Ball et al., arXiv:1110.2483; S. Alekhin et al., arXiv:1202.2281;

- 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)

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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
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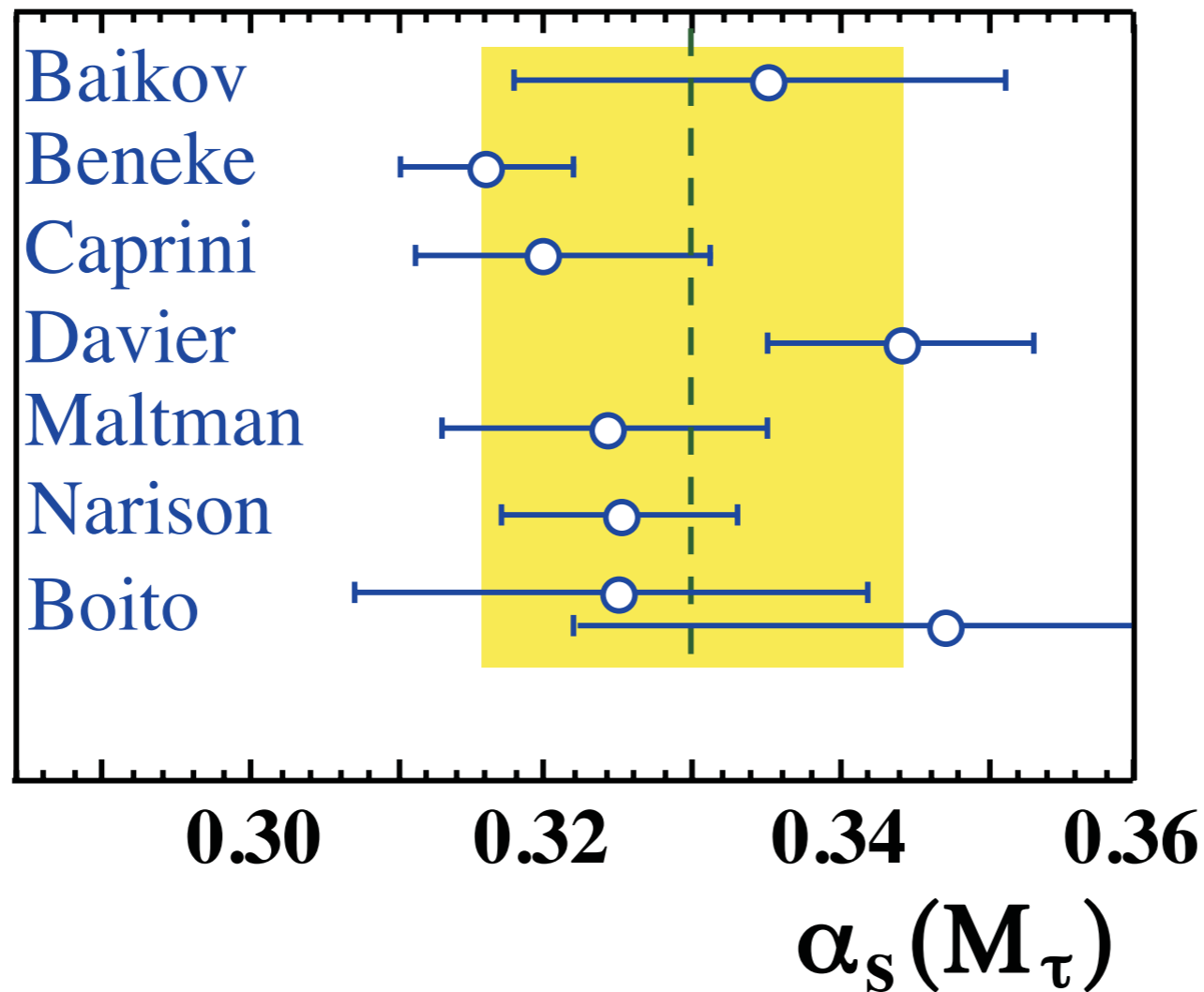
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and another difference to 2009 summary :

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

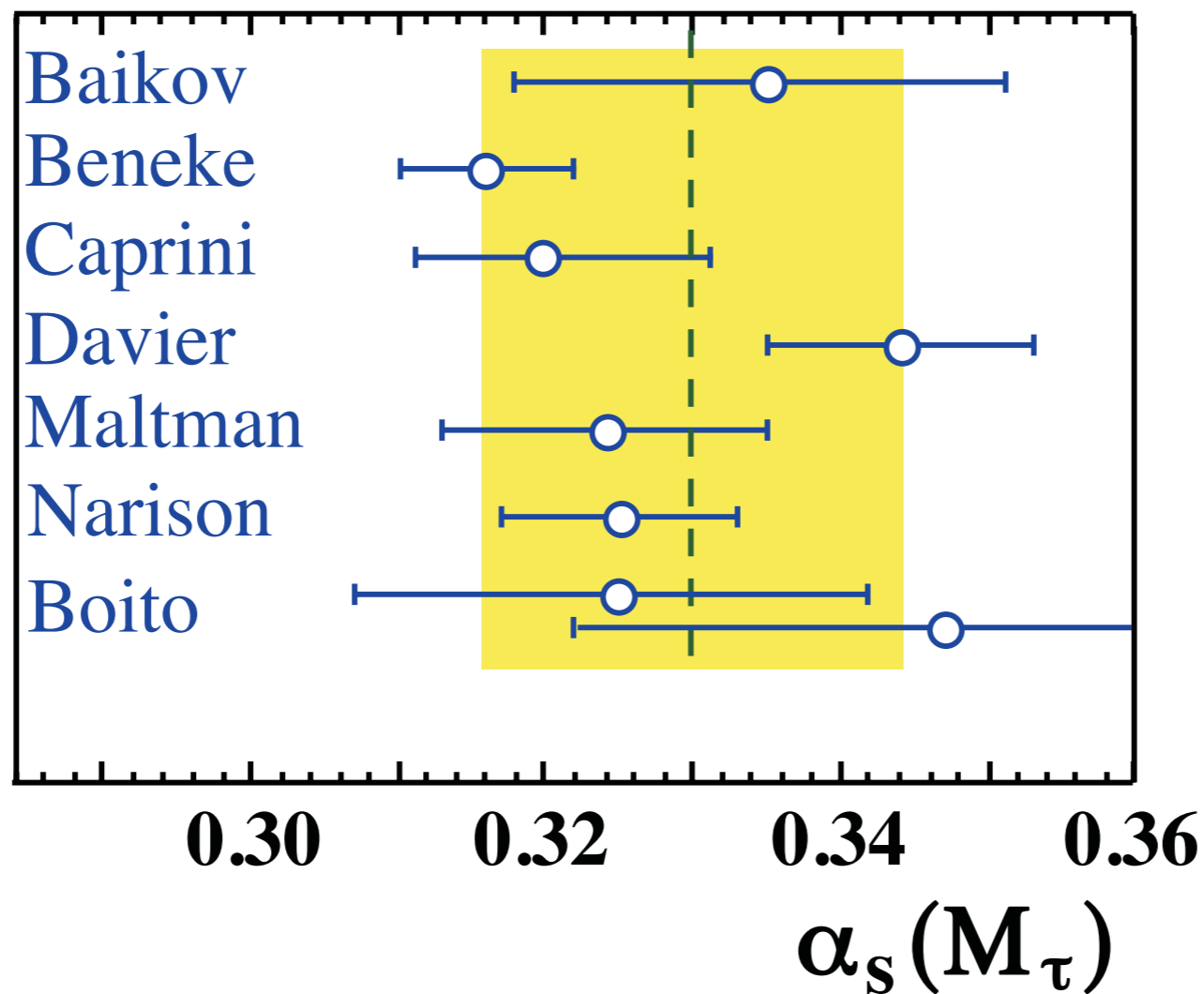
α_s from τ -decays

- 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



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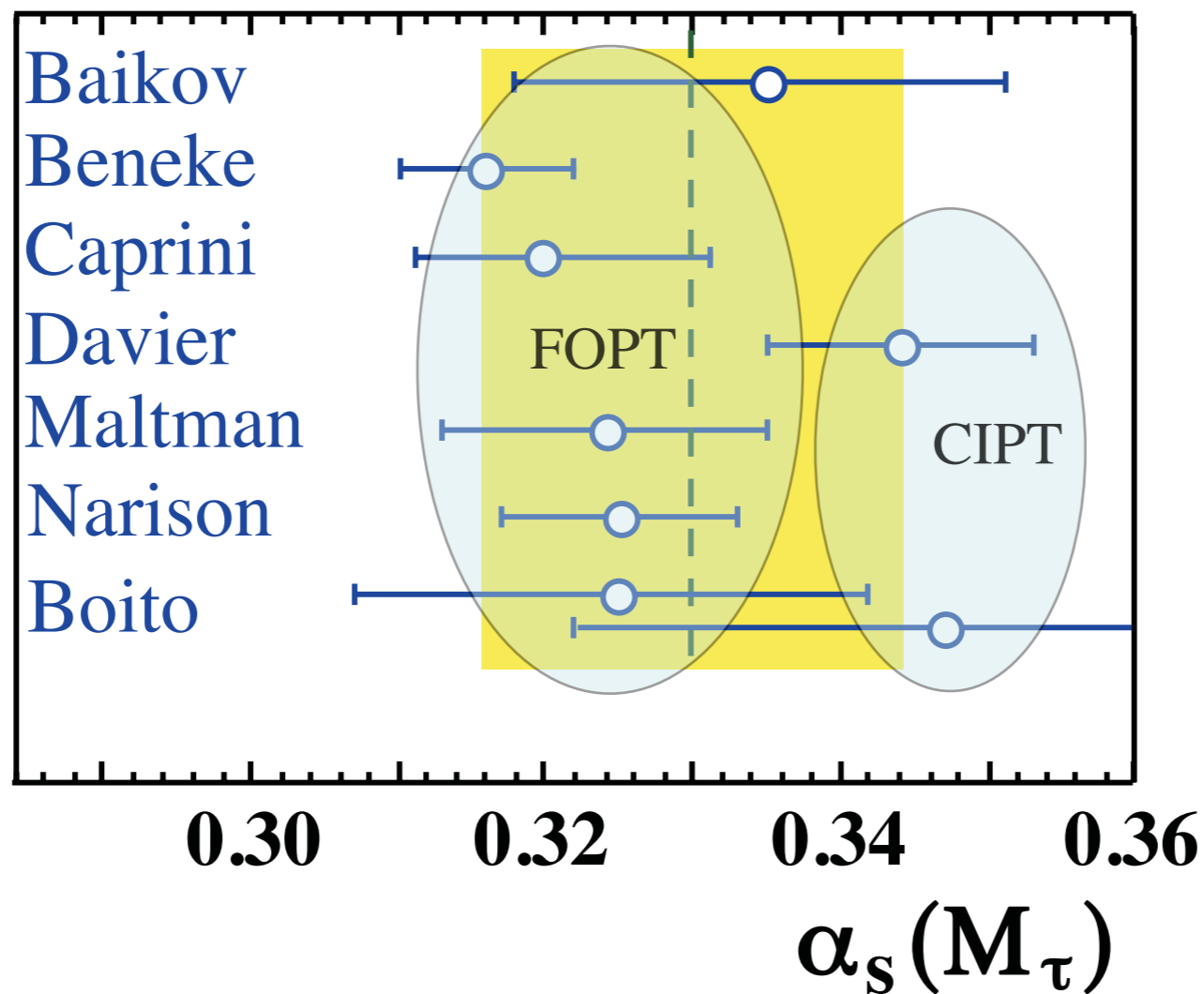
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same (sub-)sets
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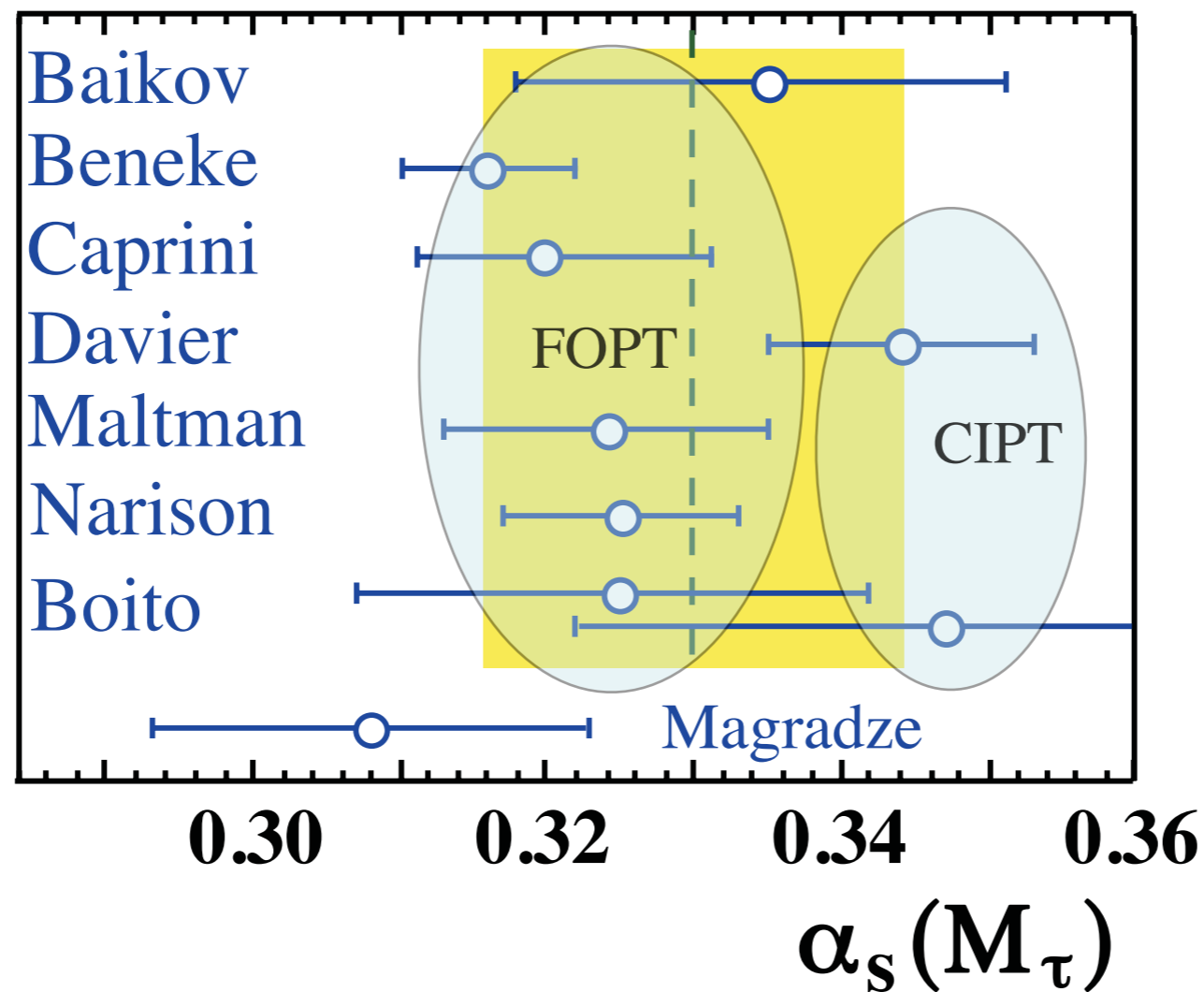
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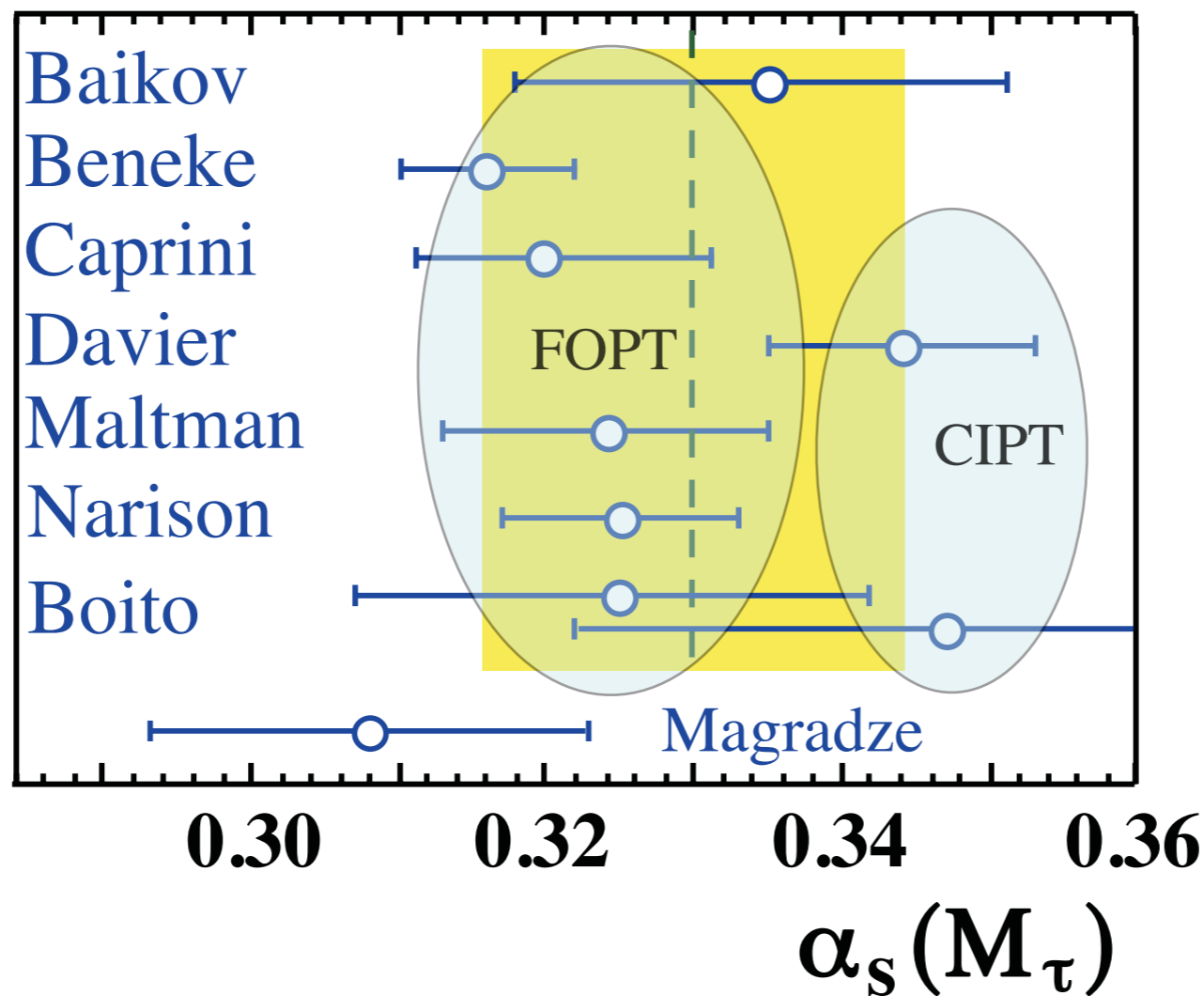
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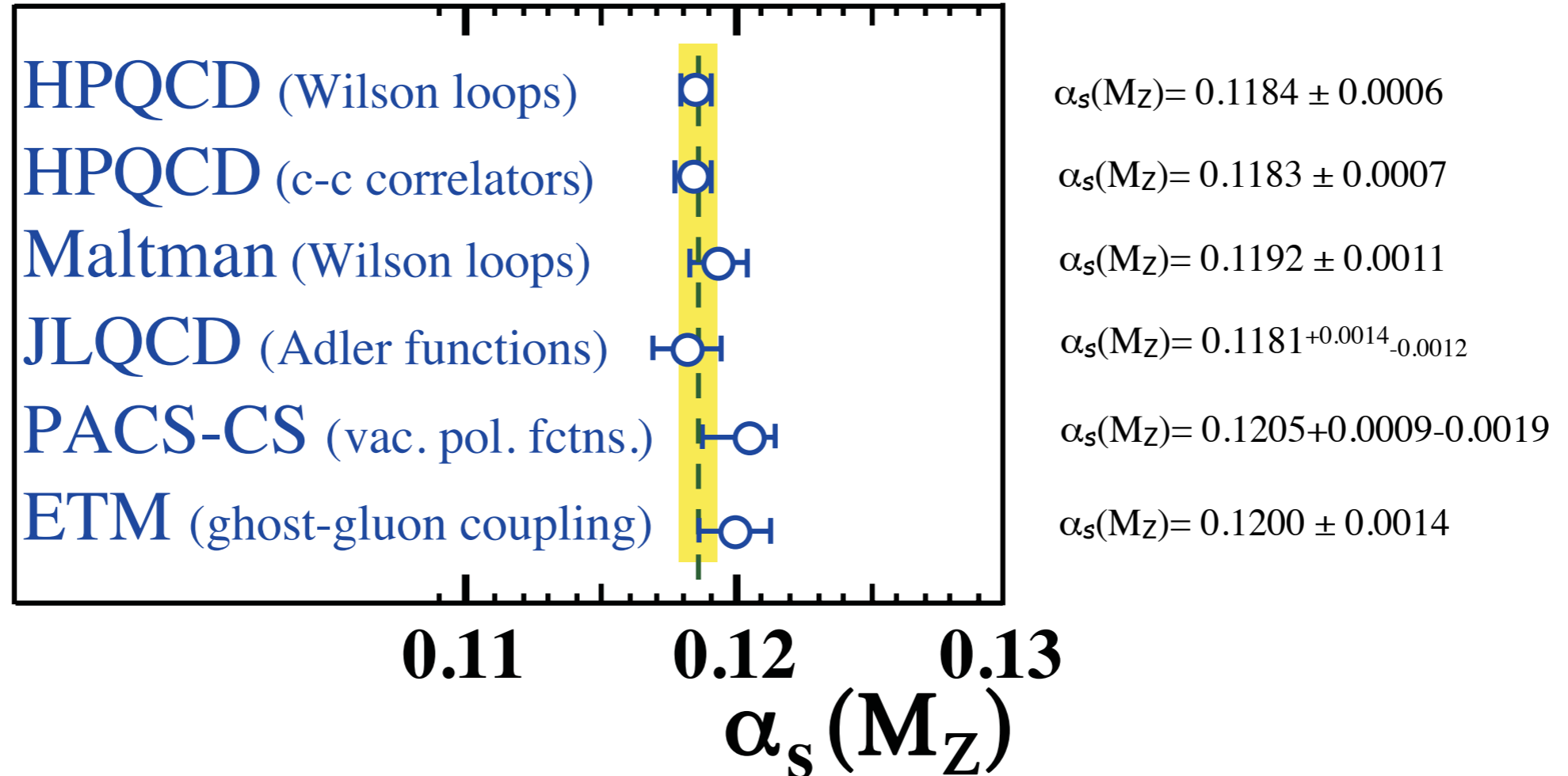


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- averaging and summarising: $\alpha_s(M_\tau) = 0.330 \pm 0.014$
 $\rightarrow \alpha_s(M_Z) = 0.1197 \pm 0.0016$

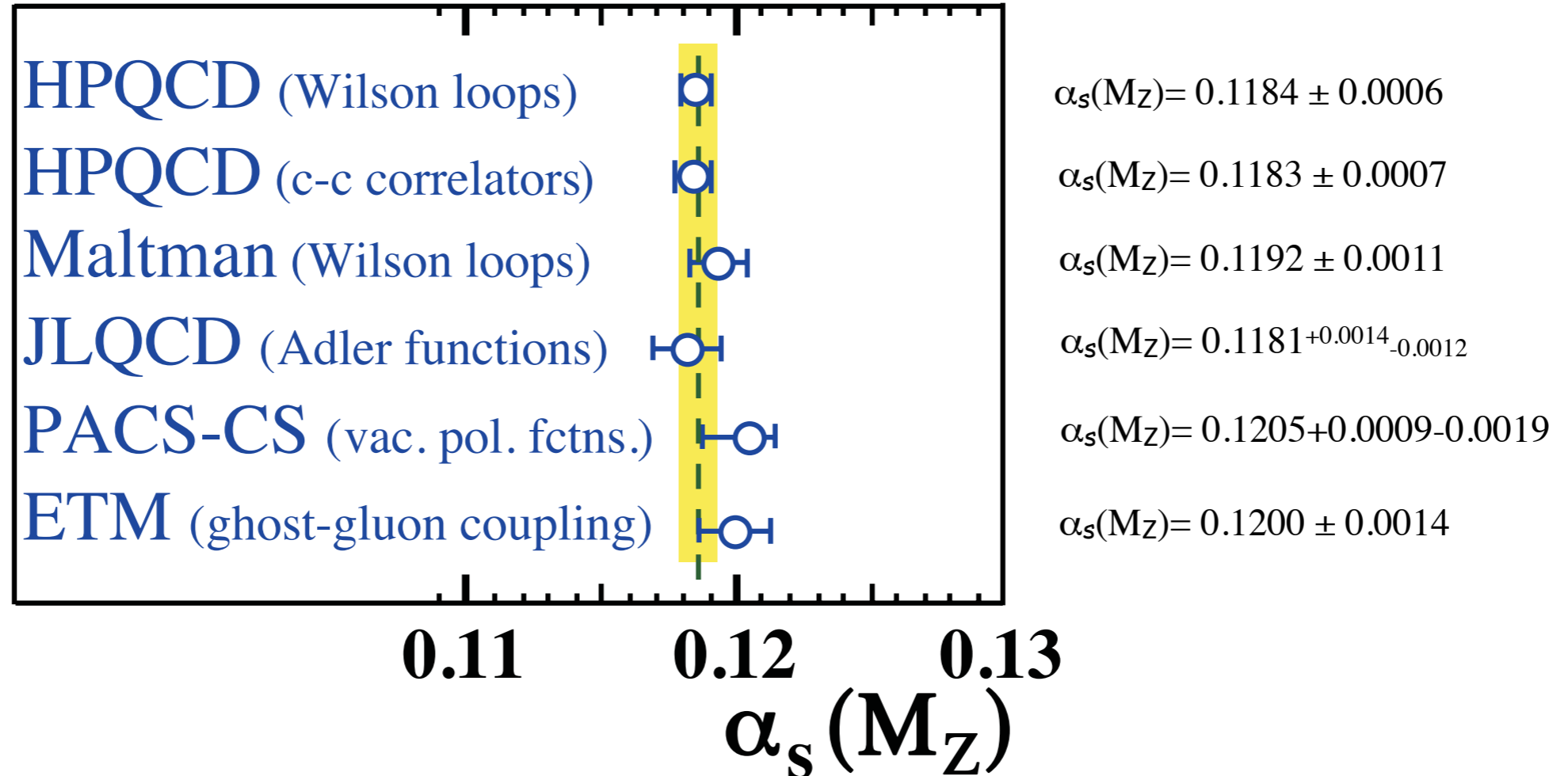
α_s from lattice QCD

- 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, ...)



α_s from lattice QCD

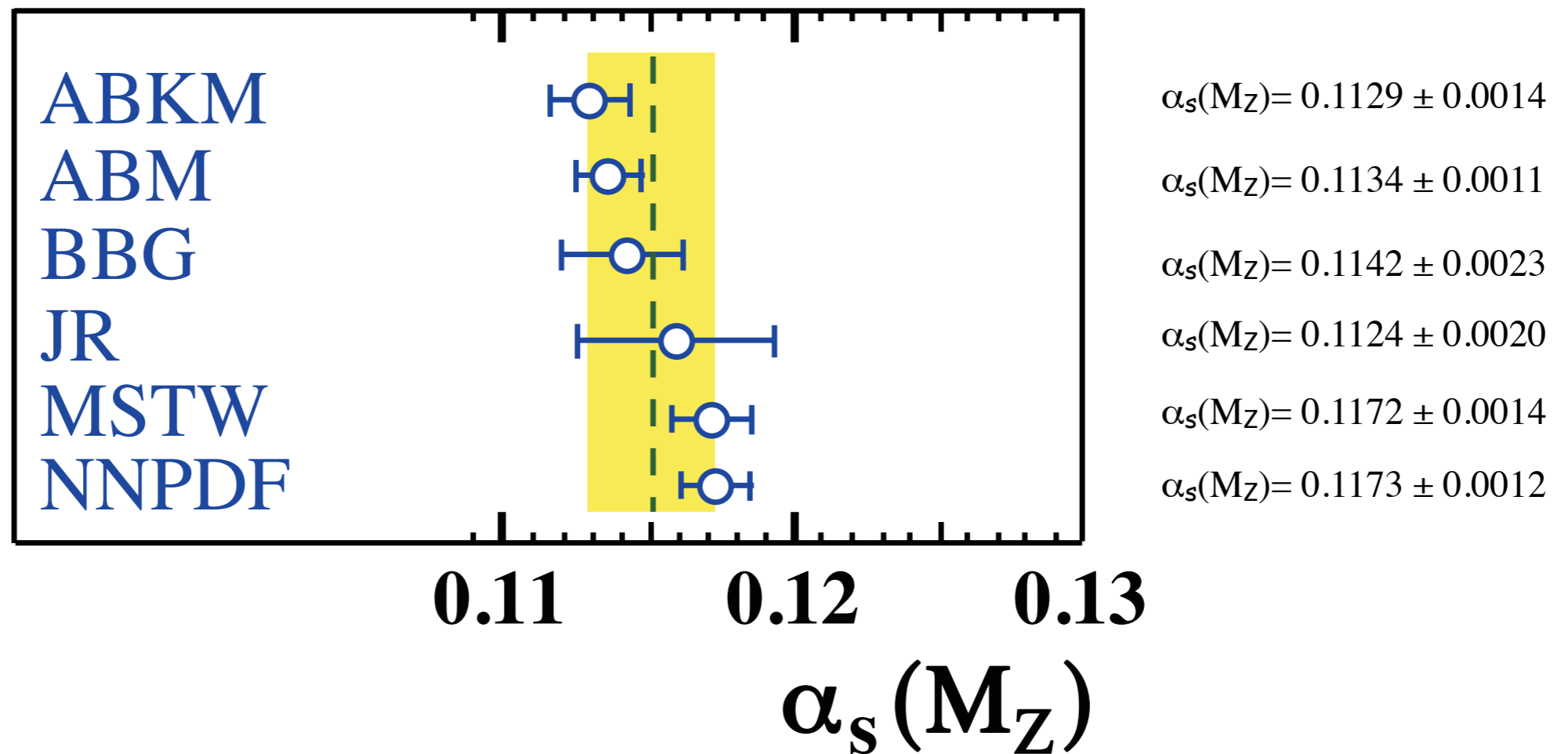
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$\rightarrow \alpha_s(M_Z) = 0.1186 \pm 0.0007$

α_s from DIS structure functions

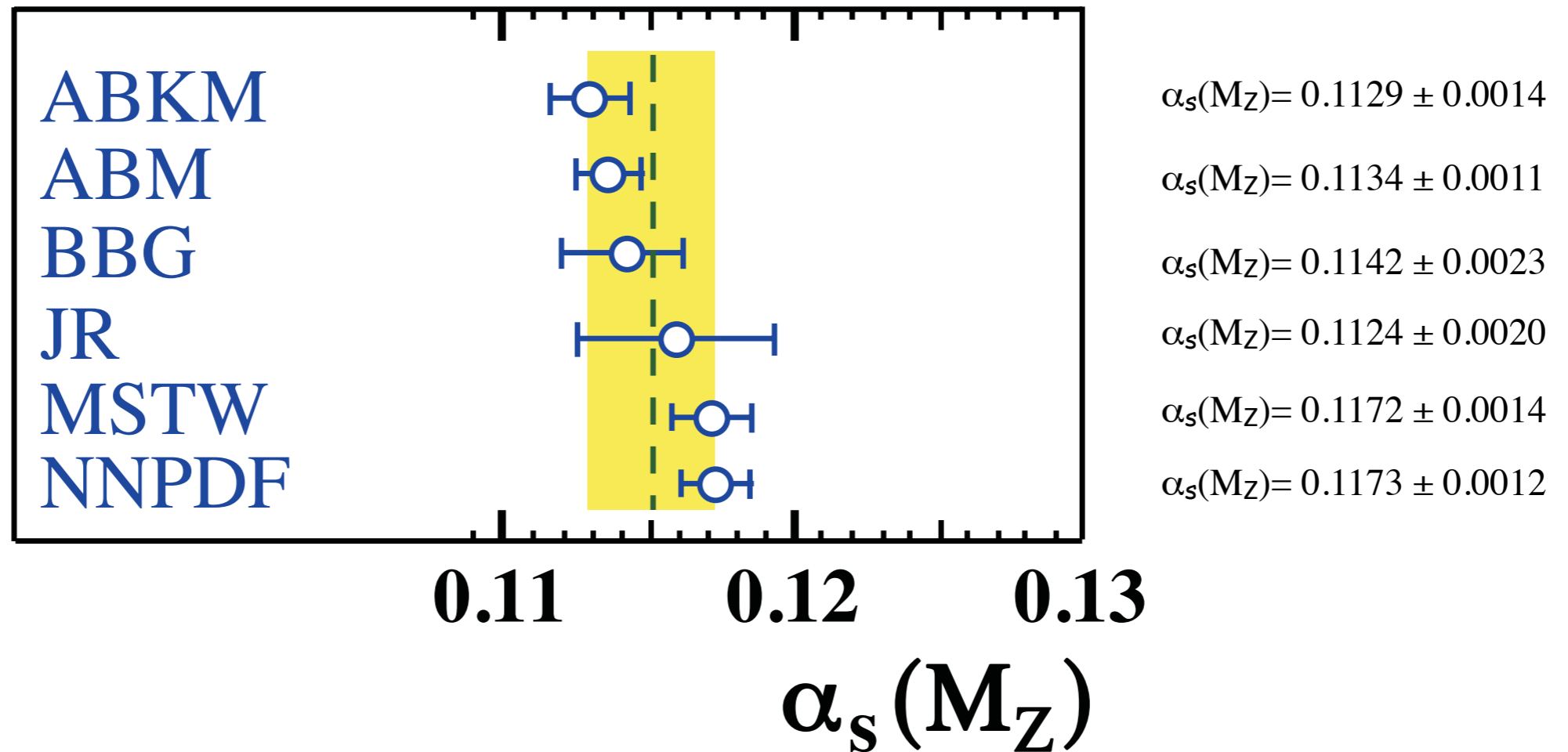
- determination of parton densities from DIS; QCD in NNLO (up to N3LO);
- MSTW/NNPDF: include hadron collider jet data (in order to constrain gluon at large x)



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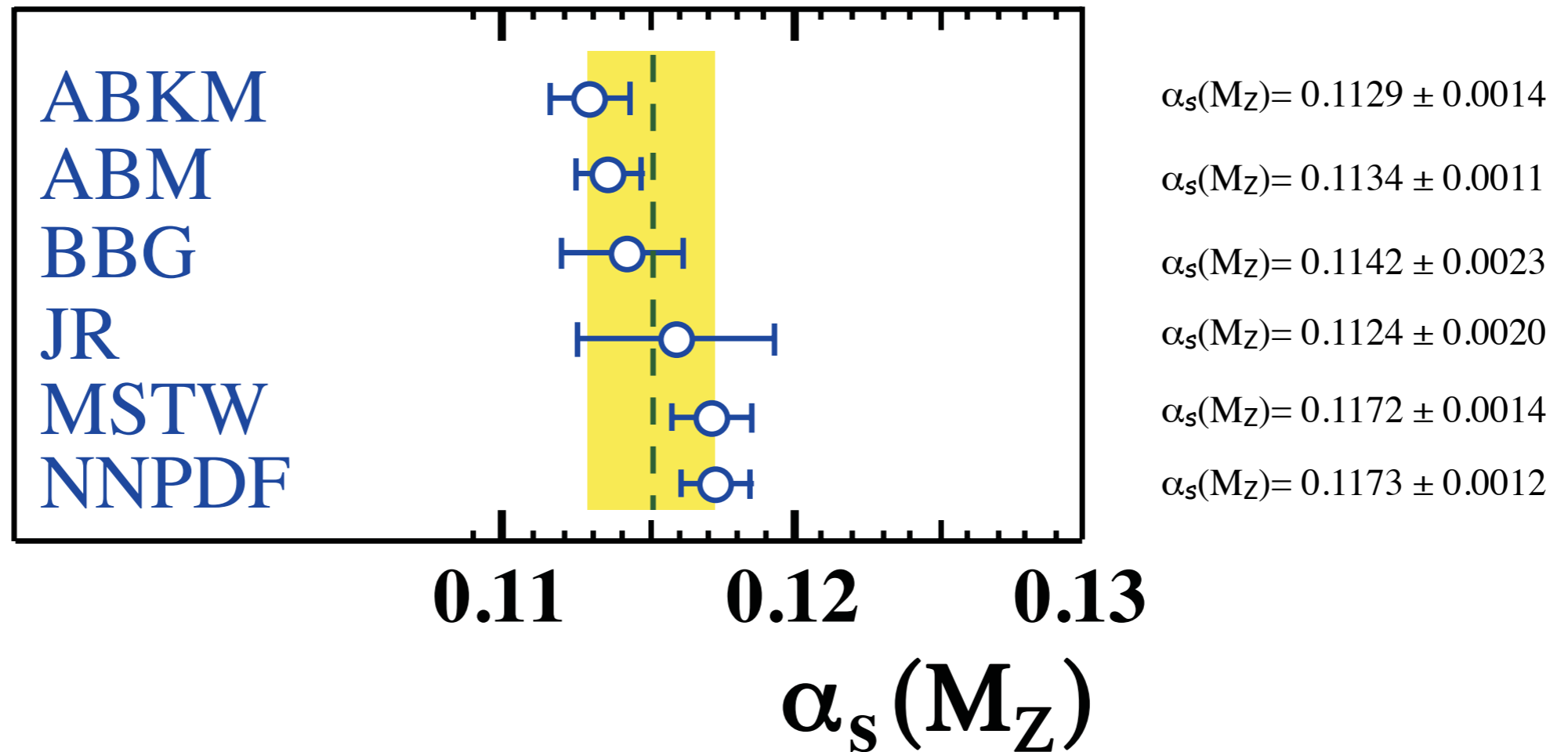
n.b.: all use same (sub-)sets of data



α_s from DIS structure functions

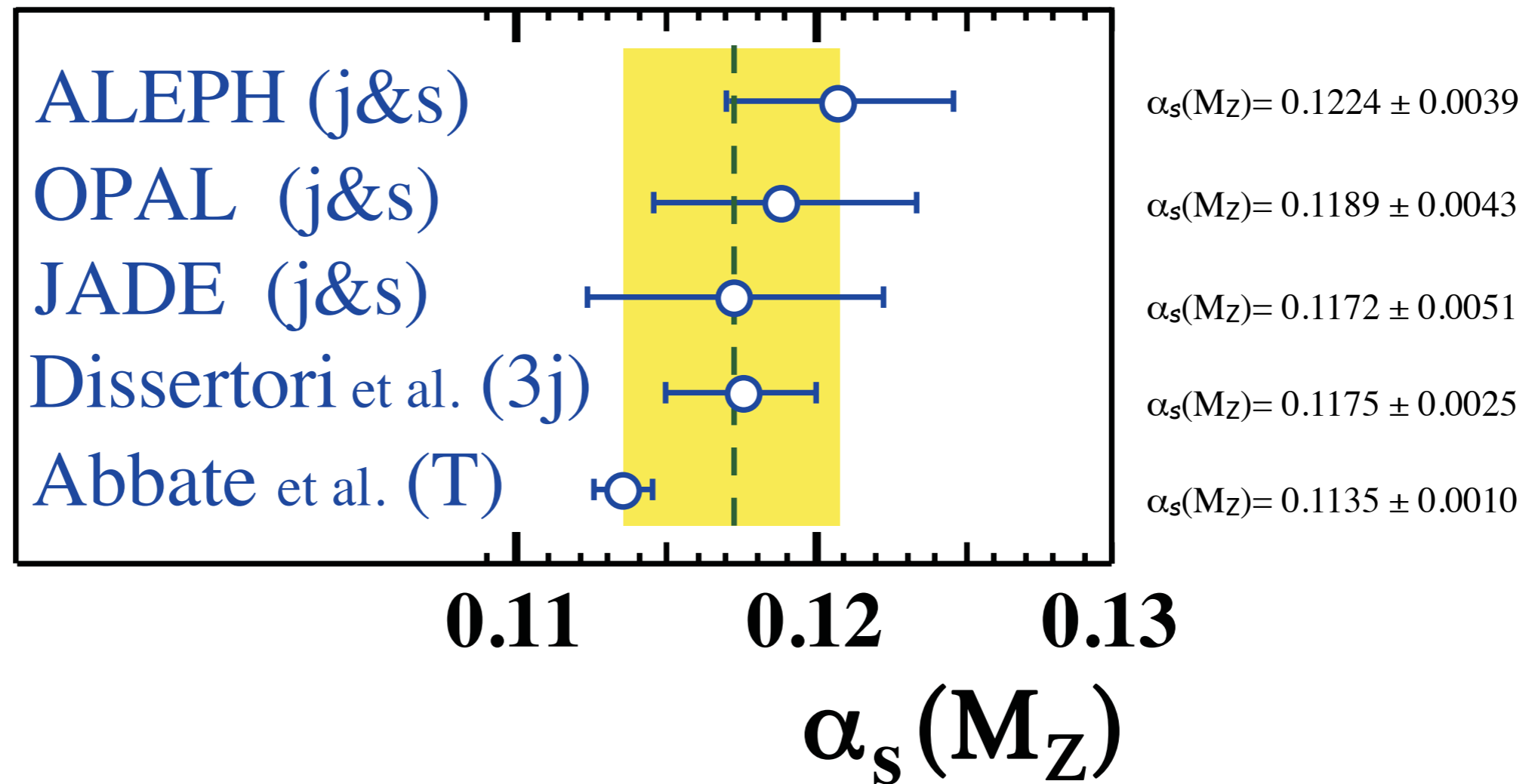
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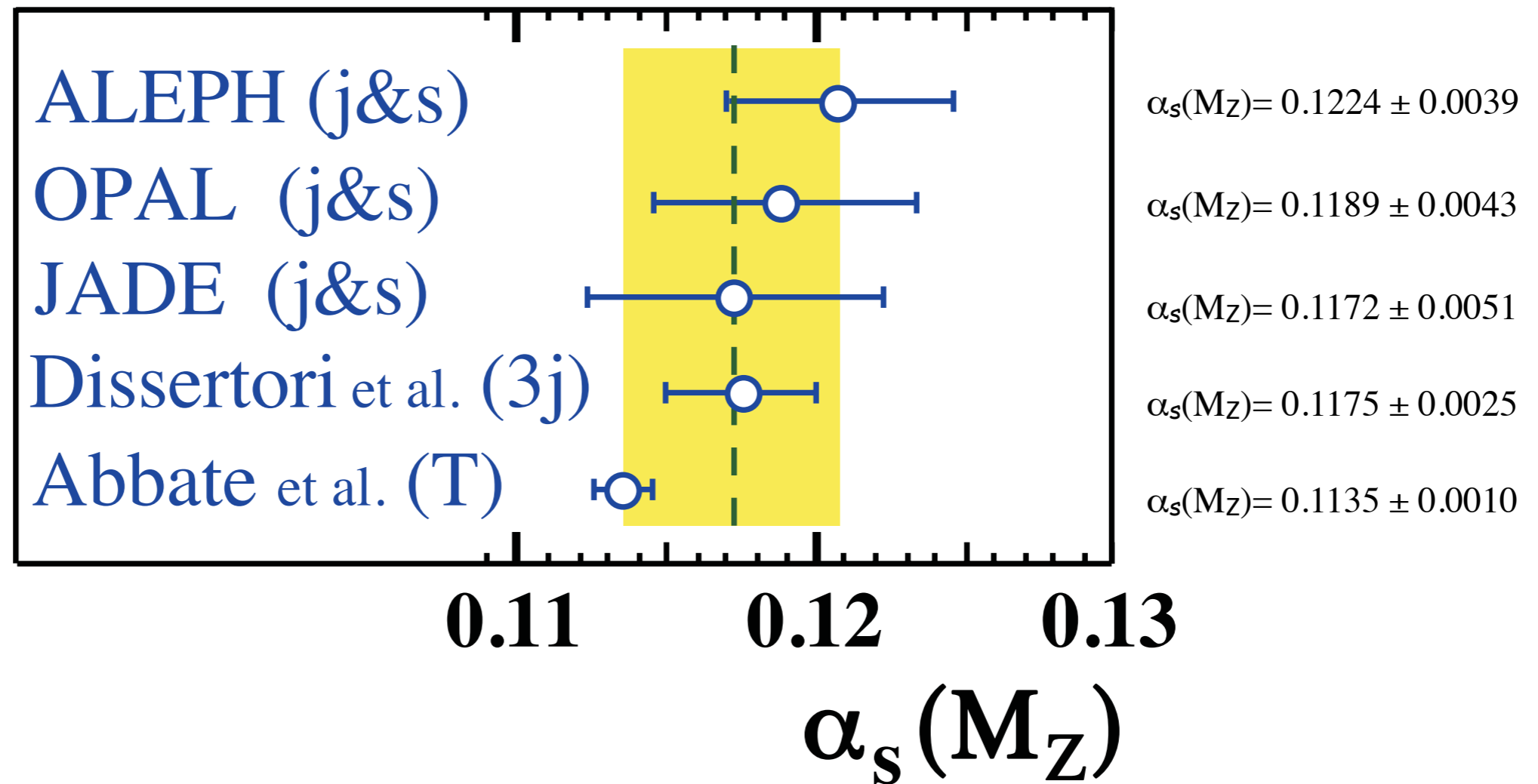


$\rightarrow \alpha_s(M_Z) = 0.1151 \pm 0.0022$

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

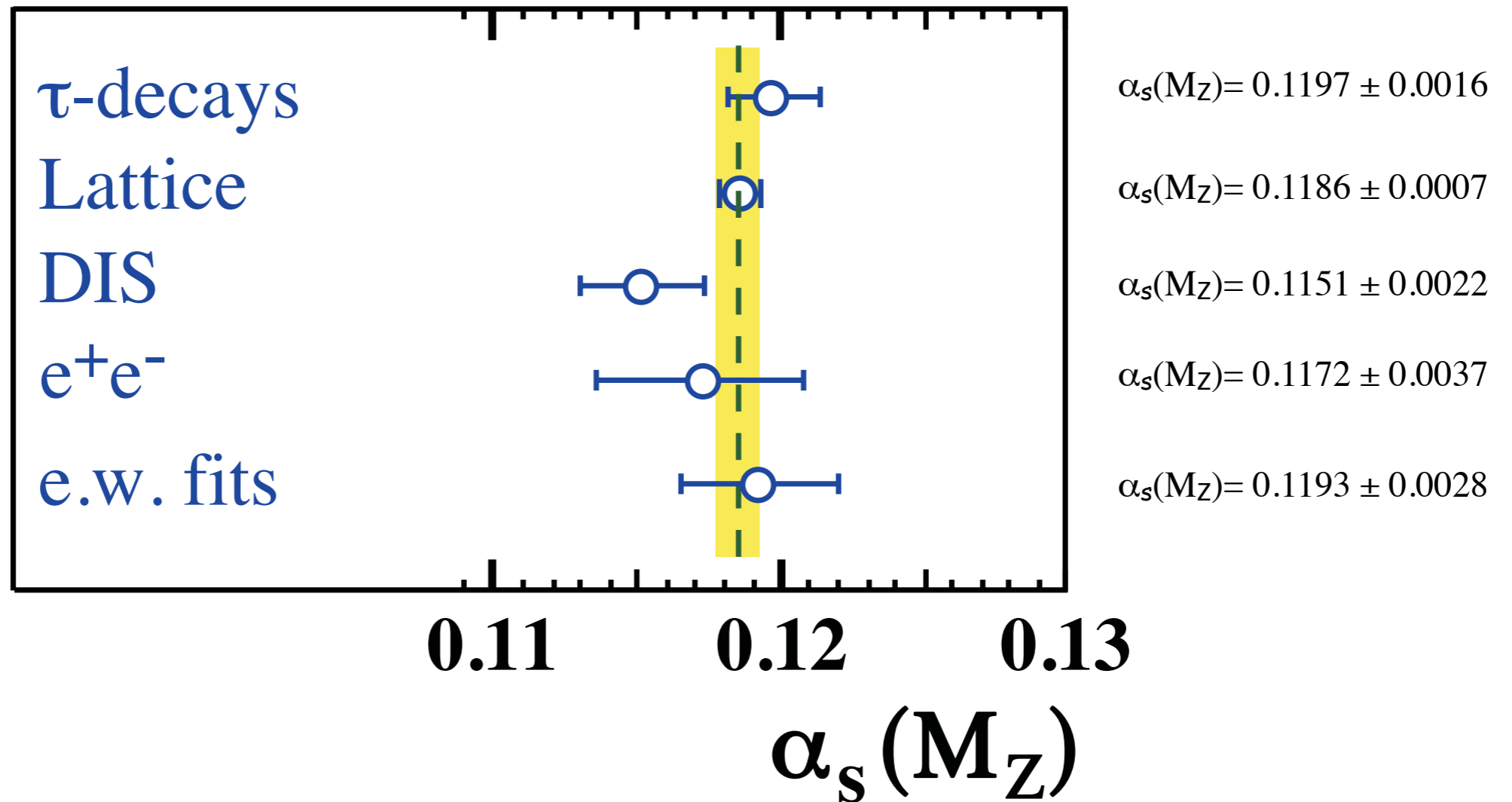


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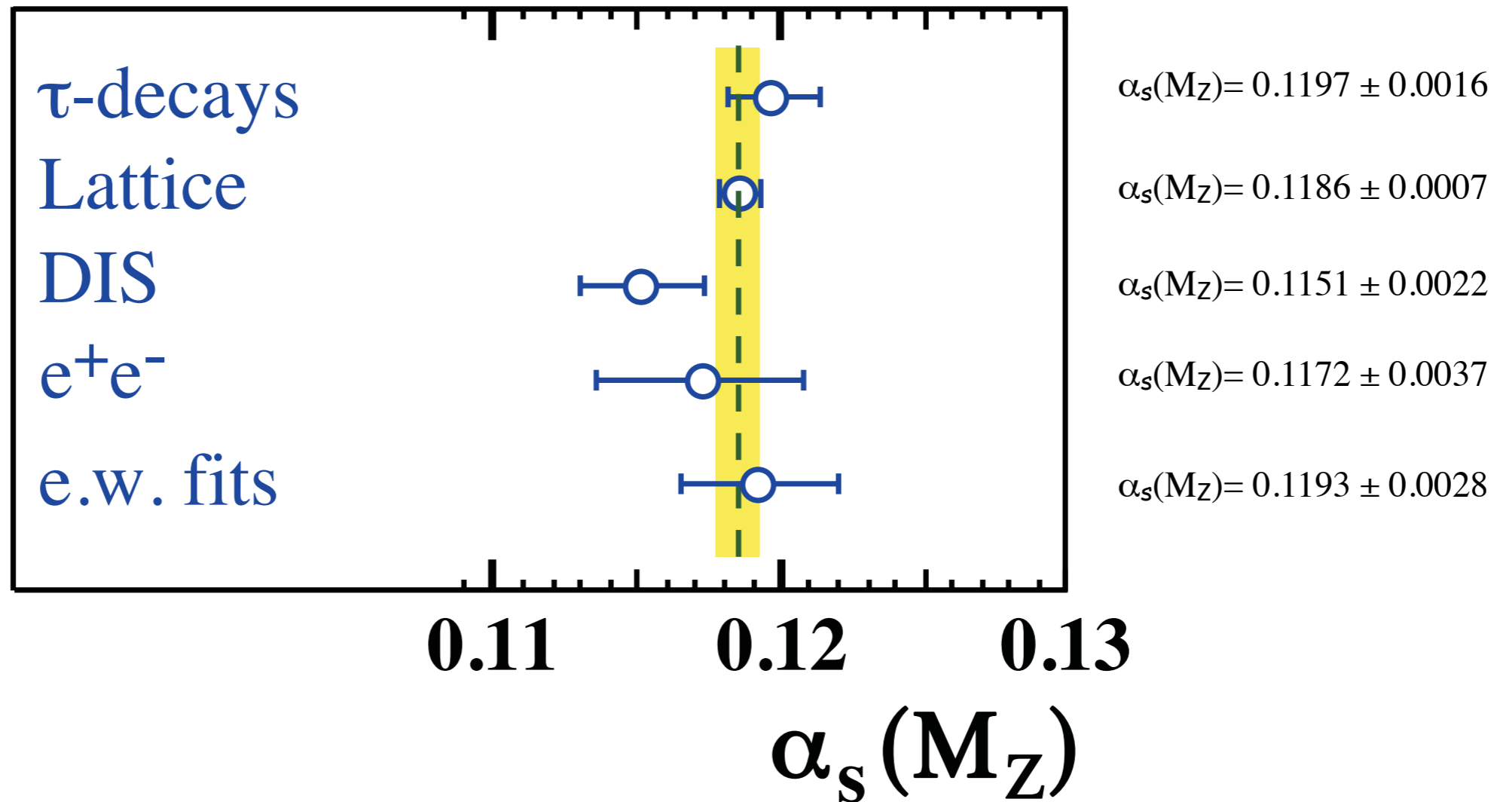


$\rightarrow \alpha_s(M_Z) = 0.1172 \pm 0.0037$

World Summary of α_s 2012:



World Summary of α_s 2012:



$\rightarrow \alpha_s(M_Z) = 0.1185 \pm 0.0007$

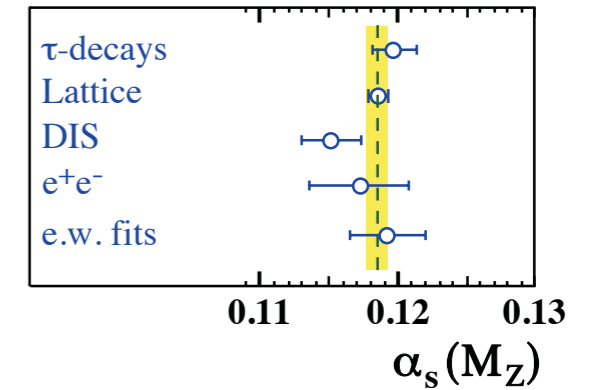
(preliminary)

$\Lambda_{\overline{\text{MS}}}^{(5)} = (214 \pm 9) \text{ MeV}$

$\Lambda_{\overline{\text{MS}}}^{(4)} = (297 \pm 11) \text{ MeV}$

World Summary of α_s 2012:

$$\alpha_s(M_Z) = 0.1185 \pm 0.0007$$



Process	$\alpha_s(M_{Z^0})$	excl. mean $\alpha_s(M_{Z^0})$	std. dev.
τ -decays	0.1197 ± 0.0016	0.1183 ± 0.0007	0.8
Lattice QCD	0.1186 ± 0.0007	0.1182 ± 0.0011	0.3
DIS [F_2]	0.1151 ± 0.0022	0.1188 ± 0.0010	1.5
e^+e^- [jets & shps]	0.1172 ± 0.0037	0.1185 ± 0.0006	0.3
ew. prec. data]	0.1192 ± 0.0028	0.1185 ± 0.0006	0.2

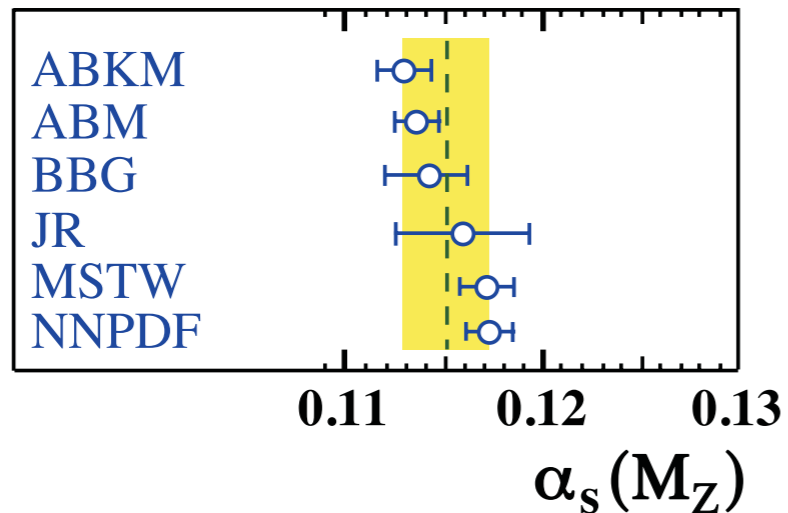
- most precise single result: from lattice QCD
- exclusive average values scatter only mildly (0.1182 ... 0.1188)
- lattice results coincides with exclusive average (w/o lattice), but largely influences overall error
- very consistent scatter of single results around overall average
- systematic unknowns in DIS / F_2 results ?

World Summary of α_s 2012:

$$\alpha_s(M_Z) = 0.1185 \pm 0.0007$$

further systematic studies: impact of *single* results

- DIS \longrightarrow ABM:

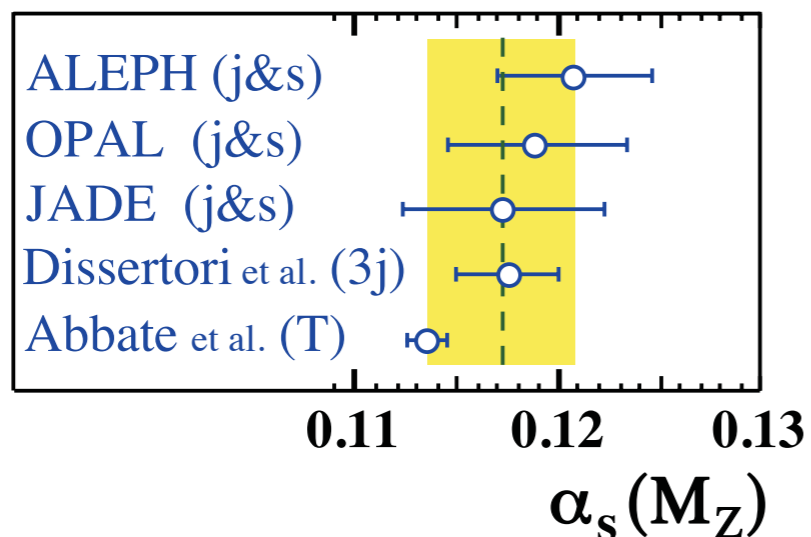


$$\alpha_s(M_Z)_{\text{DIS}} = 0.1134 \pm 0.0011$$

$$\text{w.a. } \alpha_s(M_Z) = 0.1175 \pm 0.0012$$

$$(\chi_0^2 = 18.6/4)$$

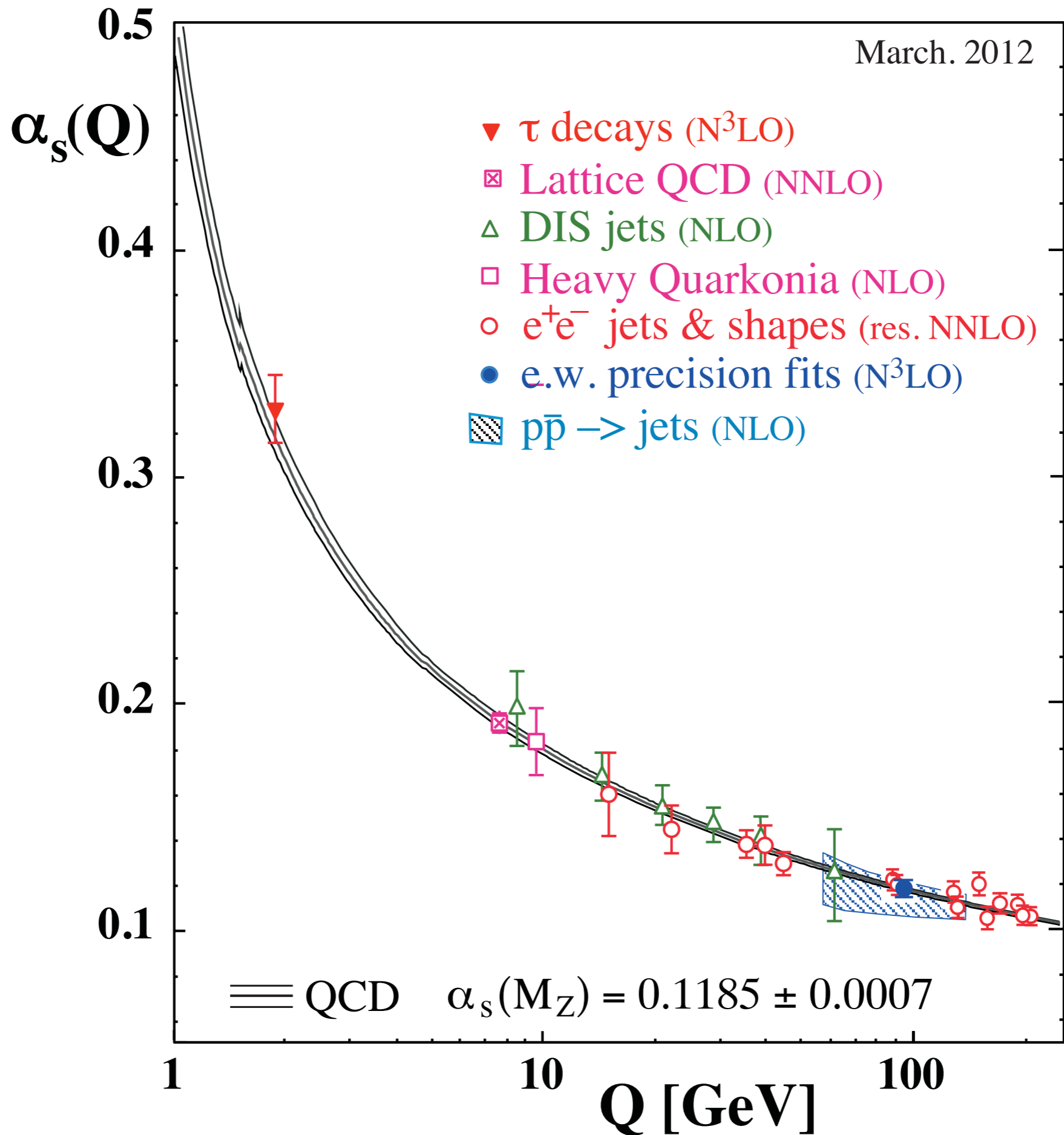
- $e^+e^- \longrightarrow$ Abbate:



$$\alpha_s(M_Z)_{e^+e^-} = 0.1135 \pm 0.0010$$

$$\text{w.a. } \alpha_s(M_Z) = 0.1172 \pm 0.0012$$

$$(\chi_0^2 = 21.6/4)$$



evidence for asymptotic freedom:

