α_s in MSTW analyses

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(Robert Thorne was looking forward to coming, but has been very ill with chicken pox. I am pleased to report he is recovering, albeit slowly)

Workshop on Precision Measurements of α_s
Munich, February 2011

MSTW2008 global fit (DIS+DY+jets) Jan.2009

NLO $\alpha_S(M_Z^2) = 0.1202$

NNLO $\alpha_S(M_Z^2) = 0.1171$

NNLO < NLO since NNLO corr lead to quicker evolution, + NNLO normalized upwards

MSTW2008 uncertainties on α_s July 2009

NLO

$$\alpha_S(M_Z^2) = 0.1202 \quad {}^{+0.0012}_{-0.0015} \text{ (68\% C.L.)} \quad {}^{+0.0032}_{-0.0039} \text{ (90\% C.L.)}$$

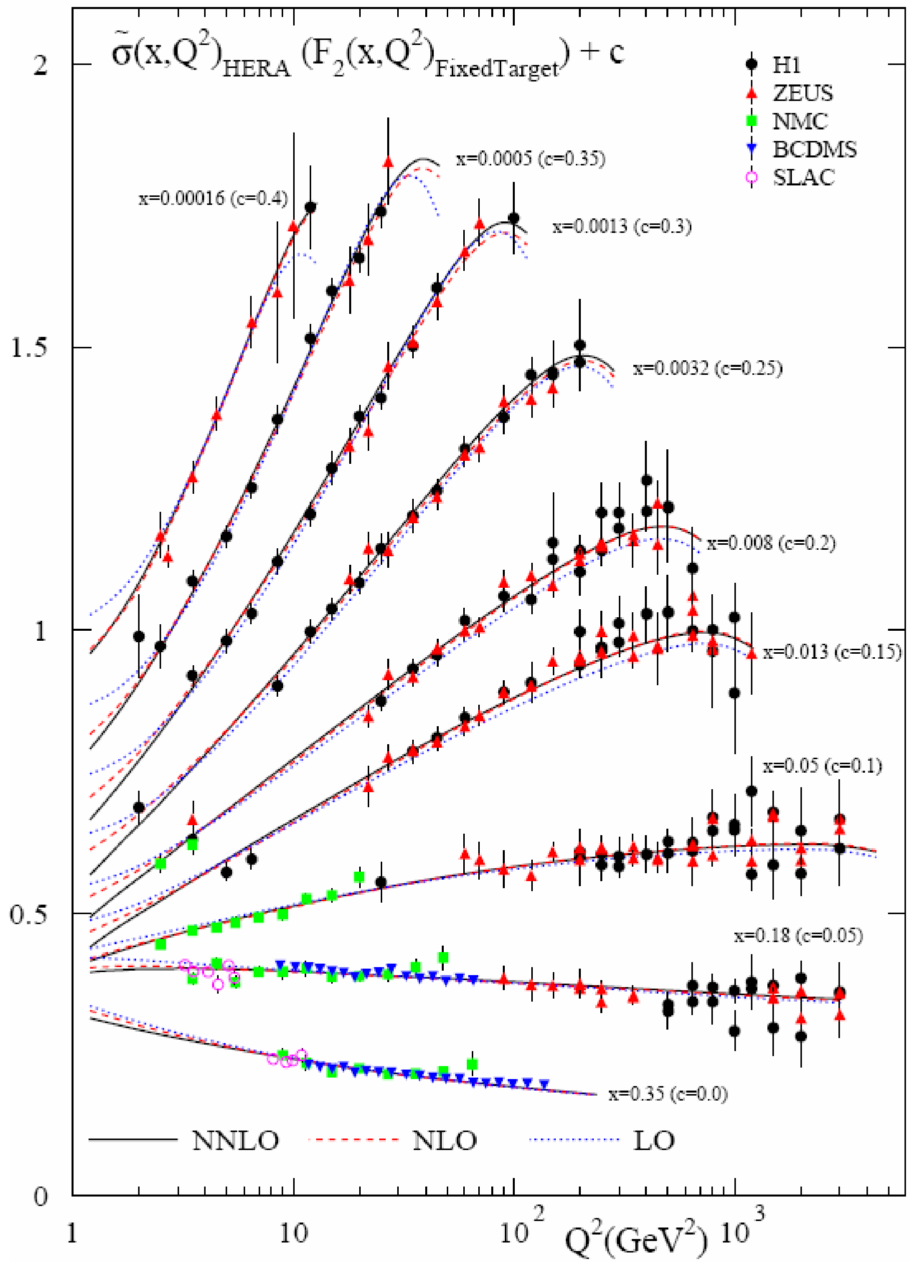
(~ ± 0.003 theory error)

NNLO

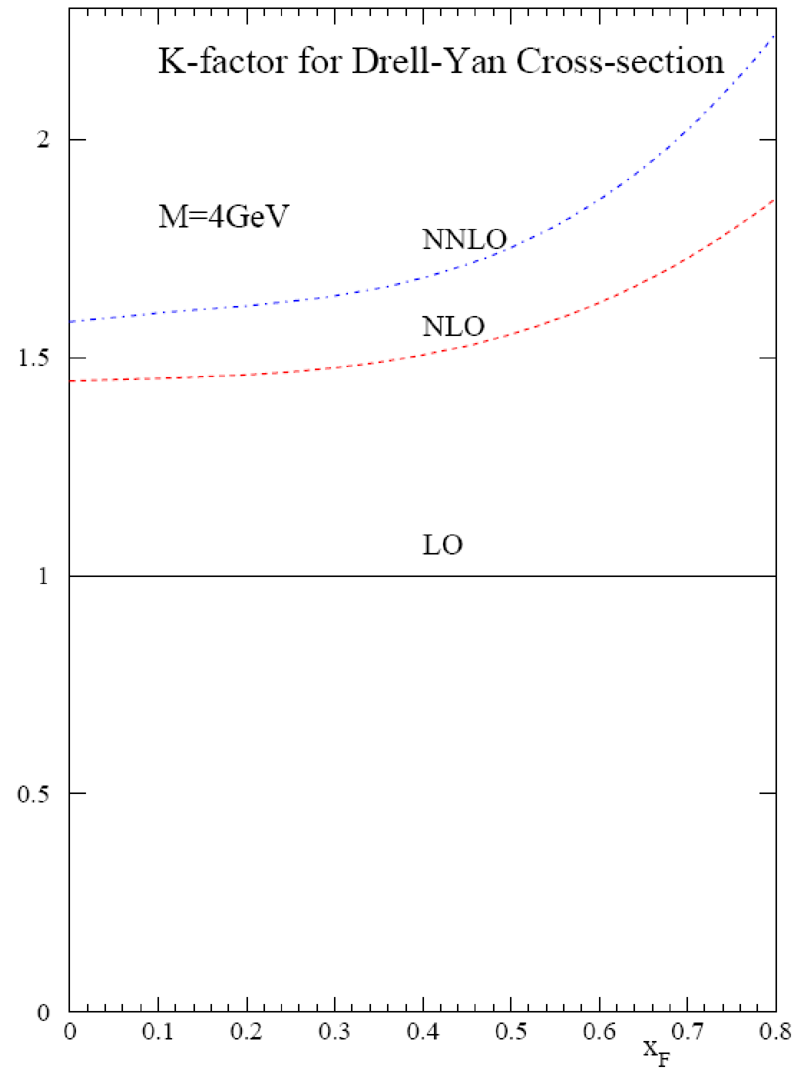
$$\alpha_S(M_Z^2) = 0.1171 \quad {}^{+0.0014}_{-0.0014} \text{ (68\% C.L.)} \quad {}^{+0.0034}_{-0.0034} \text{ (90\% C.L.)}$$

(less than ± 0.002 theory error)

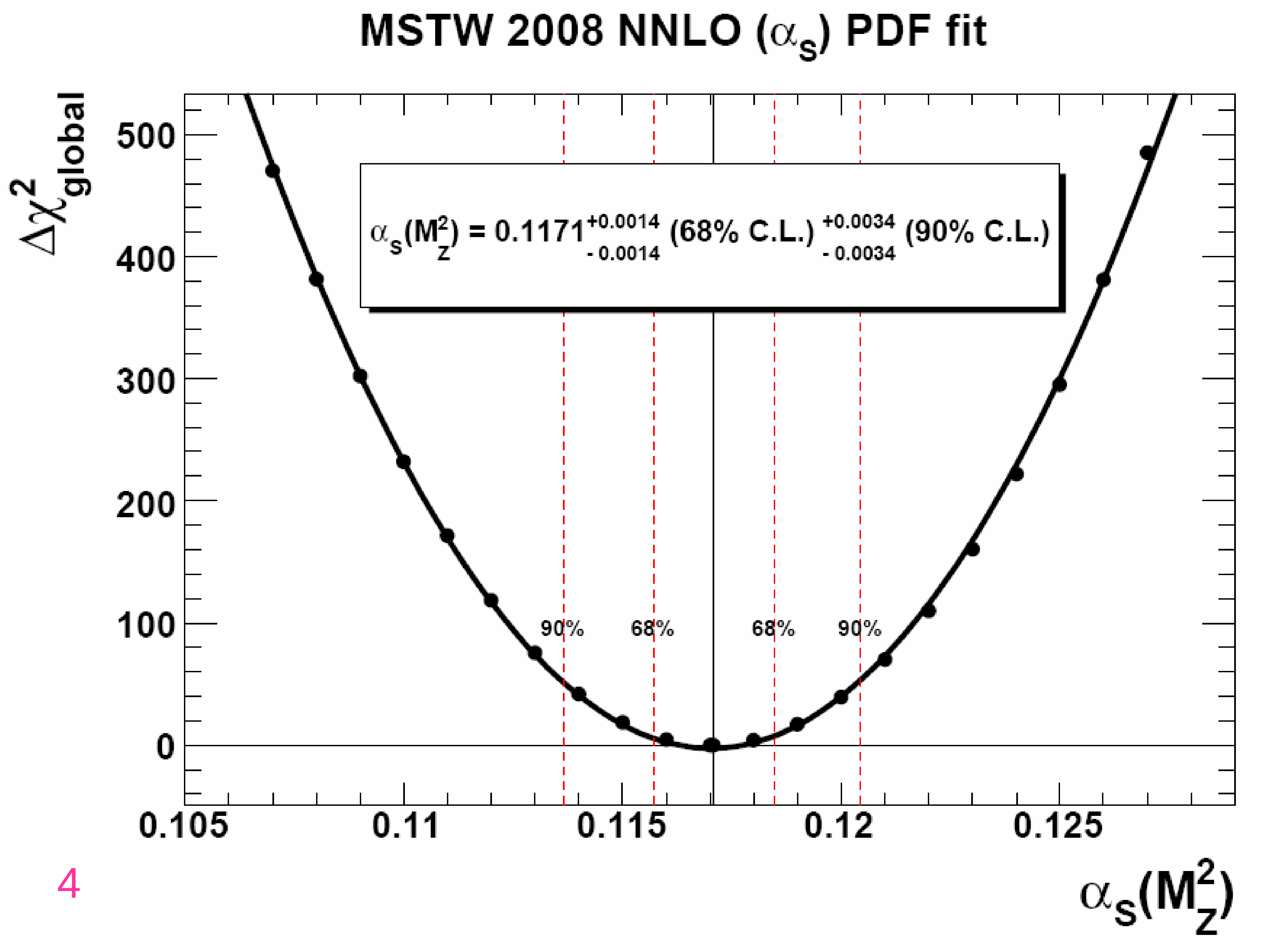
NNLO evolves faster than NLO



NNLO normalized upwards

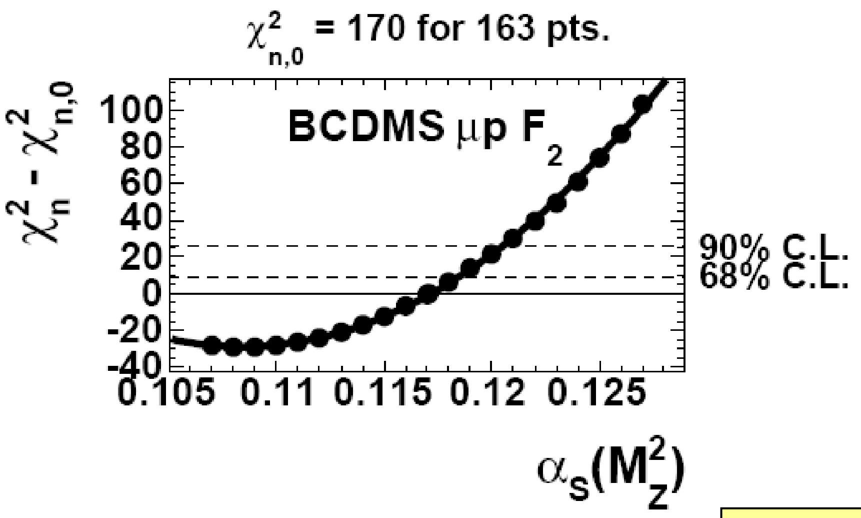


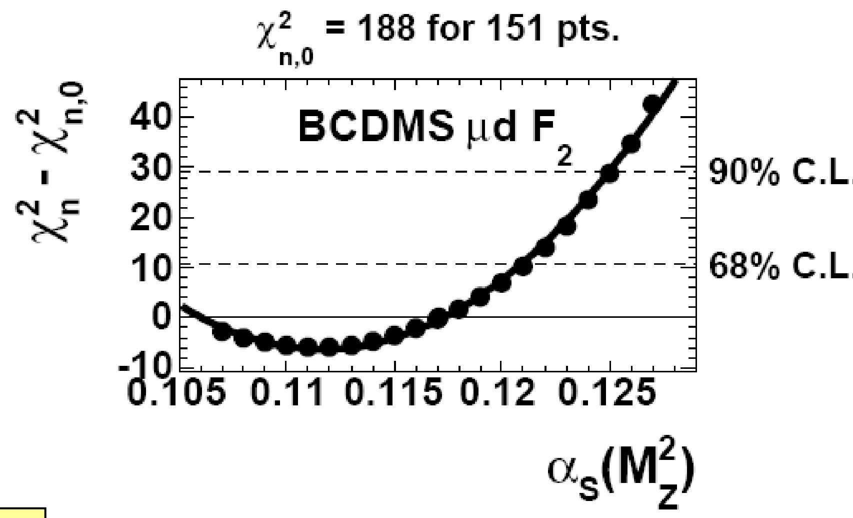
So α_s(NNLO) < α_s (NLO)


MSTW 2008 NNLO (α_S) PDF fit
$\Delta\chi^2_{global}$
$\alpha_S(M_Z^2)$ = 0.1171$^{+0.0014}_{-0.0014}$ (68% C.L.) $^{+0.0034}_{-0.0034}$ (90% C.L.)
90%
68%
68%
90%
500
400
300
200
100
0
0.105
0.11
0.115
0.12
0.125
$\alpha_S(M_Z^2)$

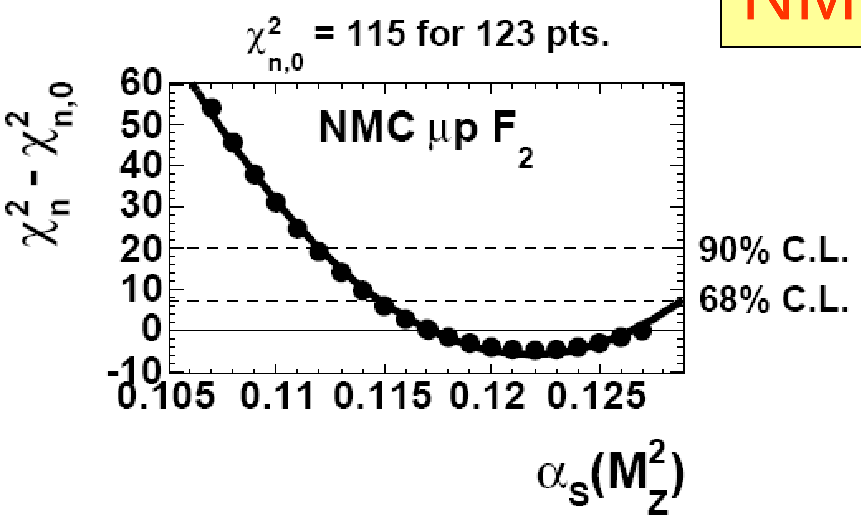
NNLO

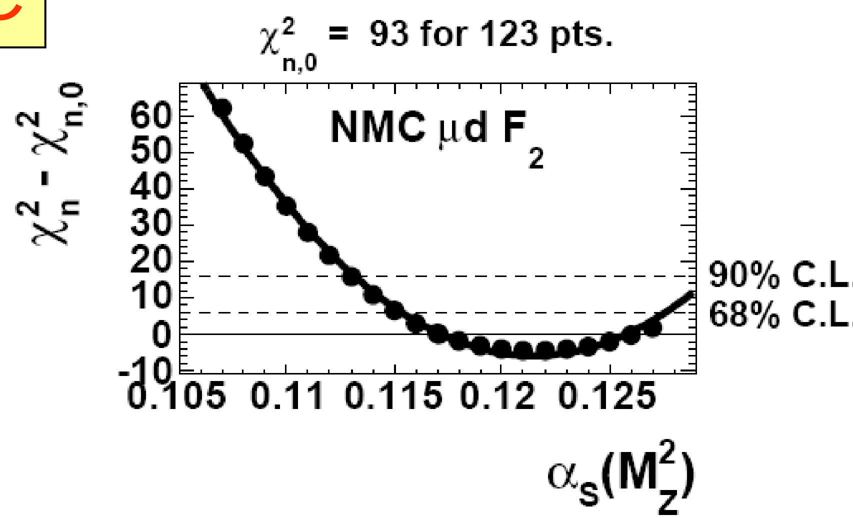
BCDMS – favours low α_s





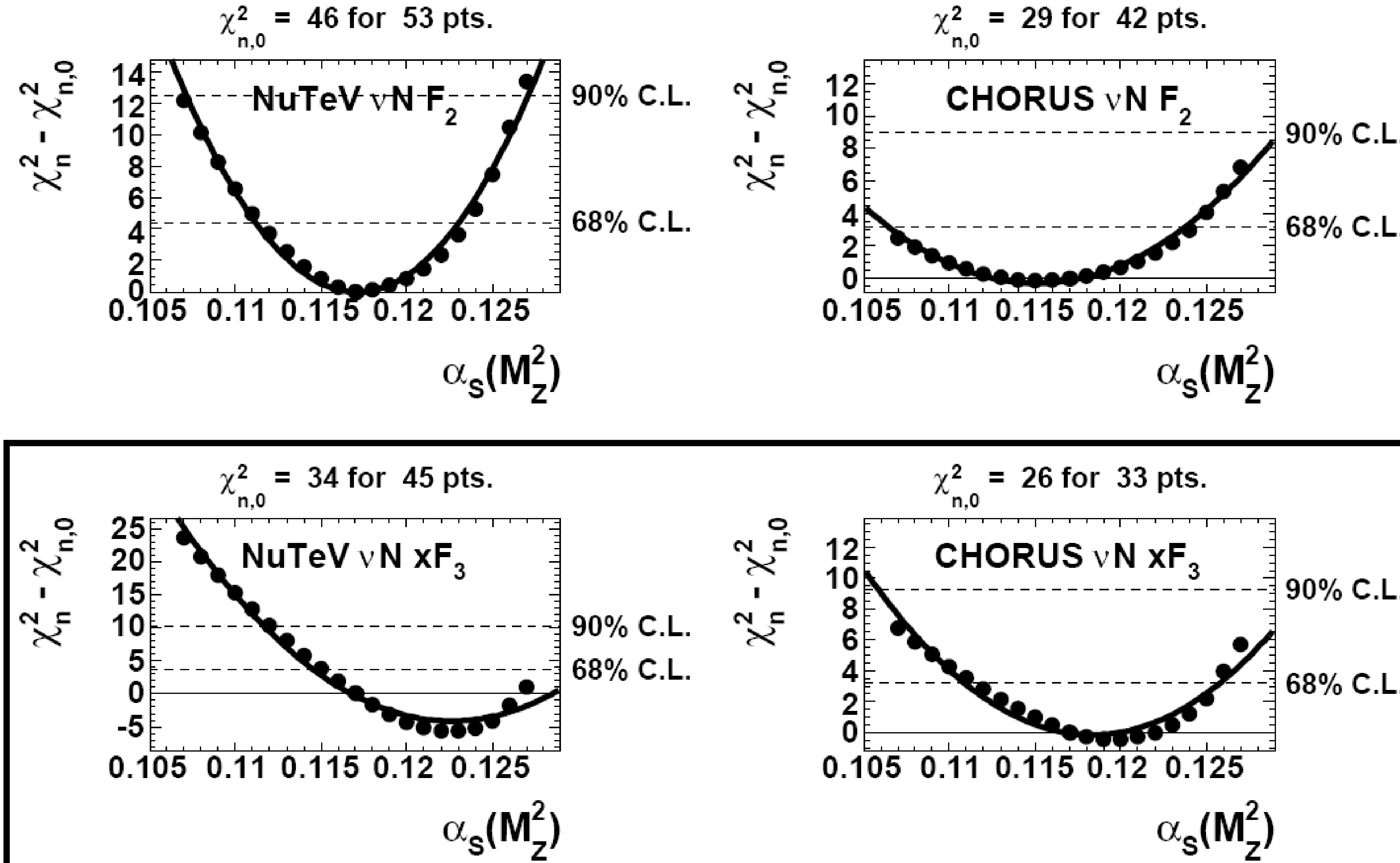
NMC





NNLO

neutrino F_2, xF_3

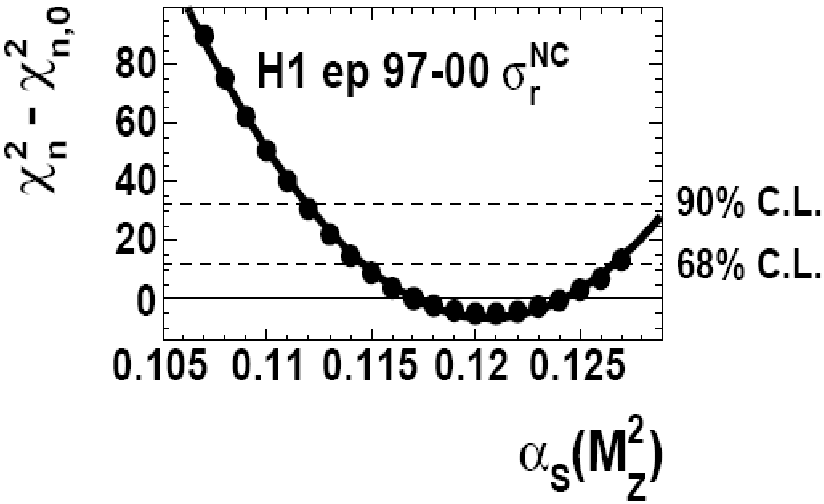


xF_3 pure non-singlet: $\alpha_s \sim 0.12$

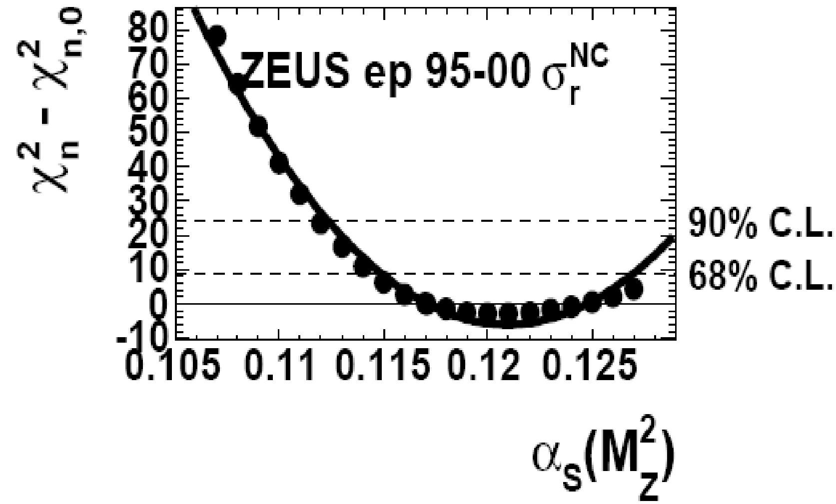
NNLO

HERA F_2

$\chi^2_{n,0}$ = 360 for 425 pts.

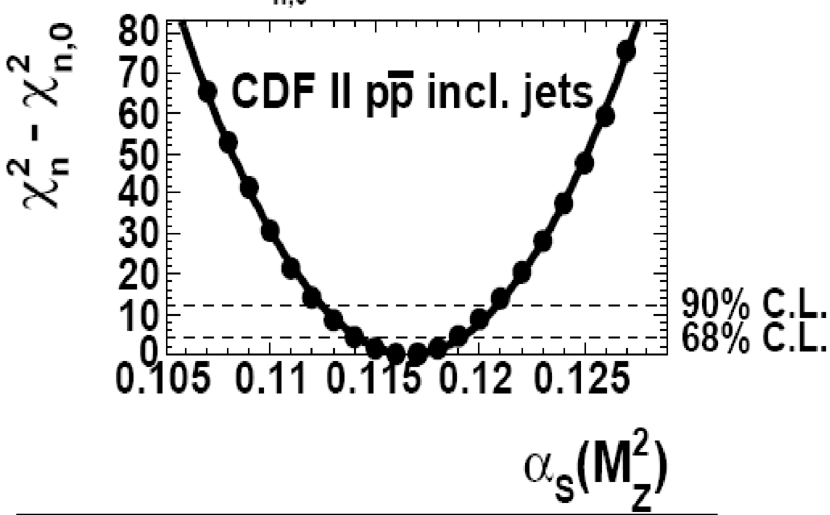


$\chi^2_{n,0}$ = 241 for 356 pts.

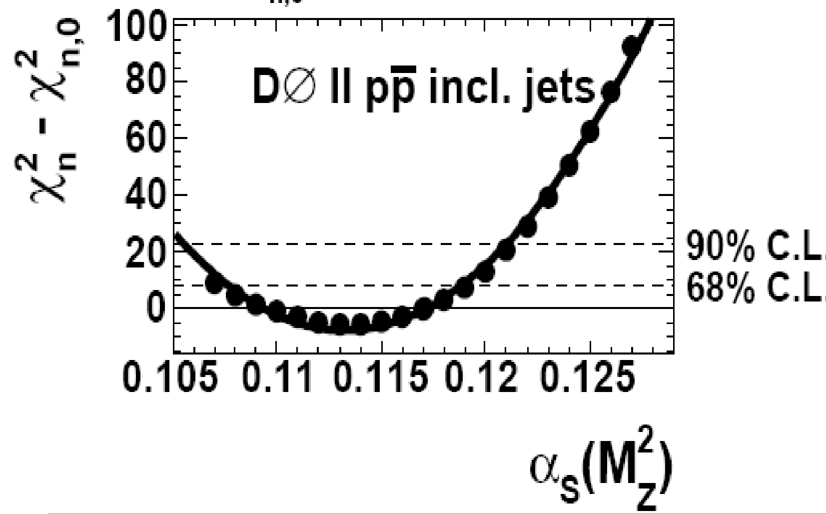


Tevatron jets

$\chi^2_{n,0}$ = 54 for 76 pts.



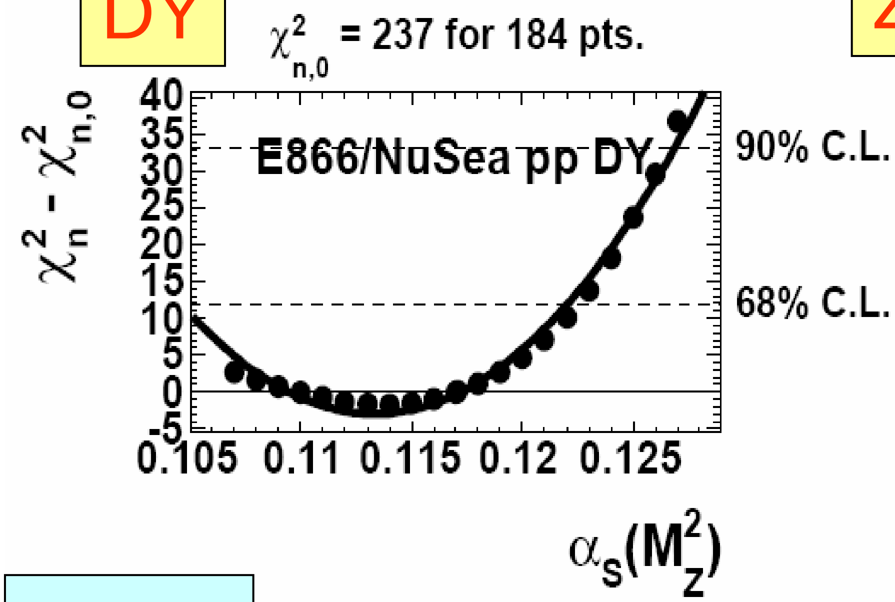
$\chi^2_{n,0}$ = 123 for 110 pts.



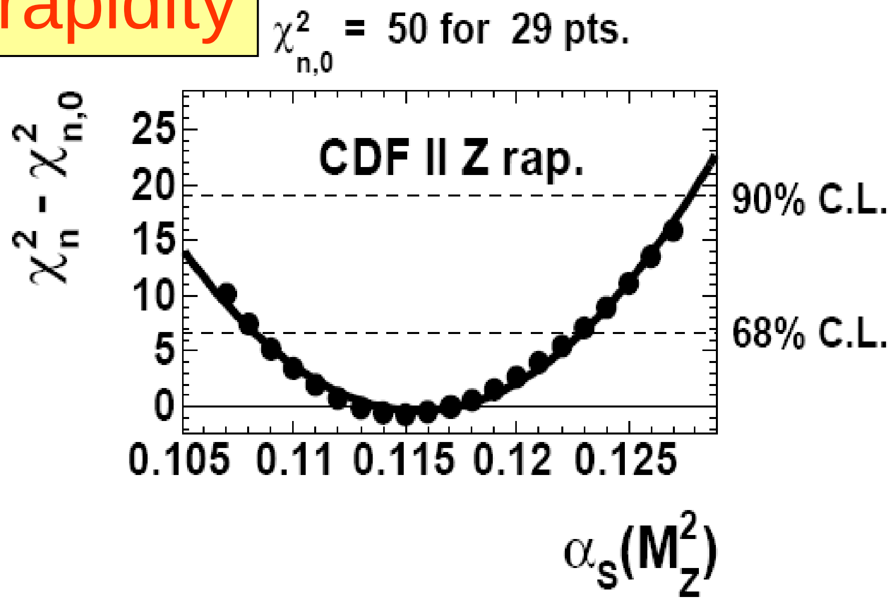
CDF v. constraining – see later

NNLO corr. approx by threshold resum

DY

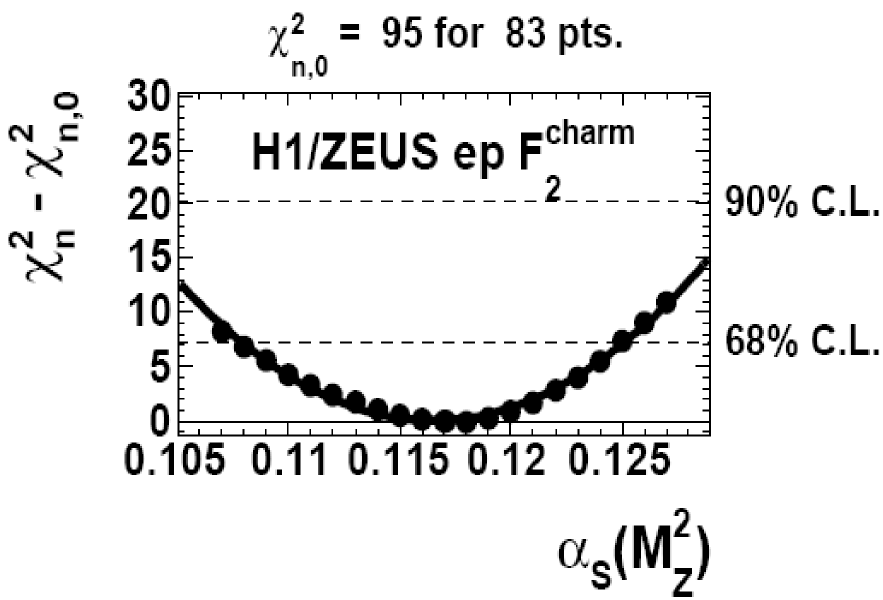


Z rapidity



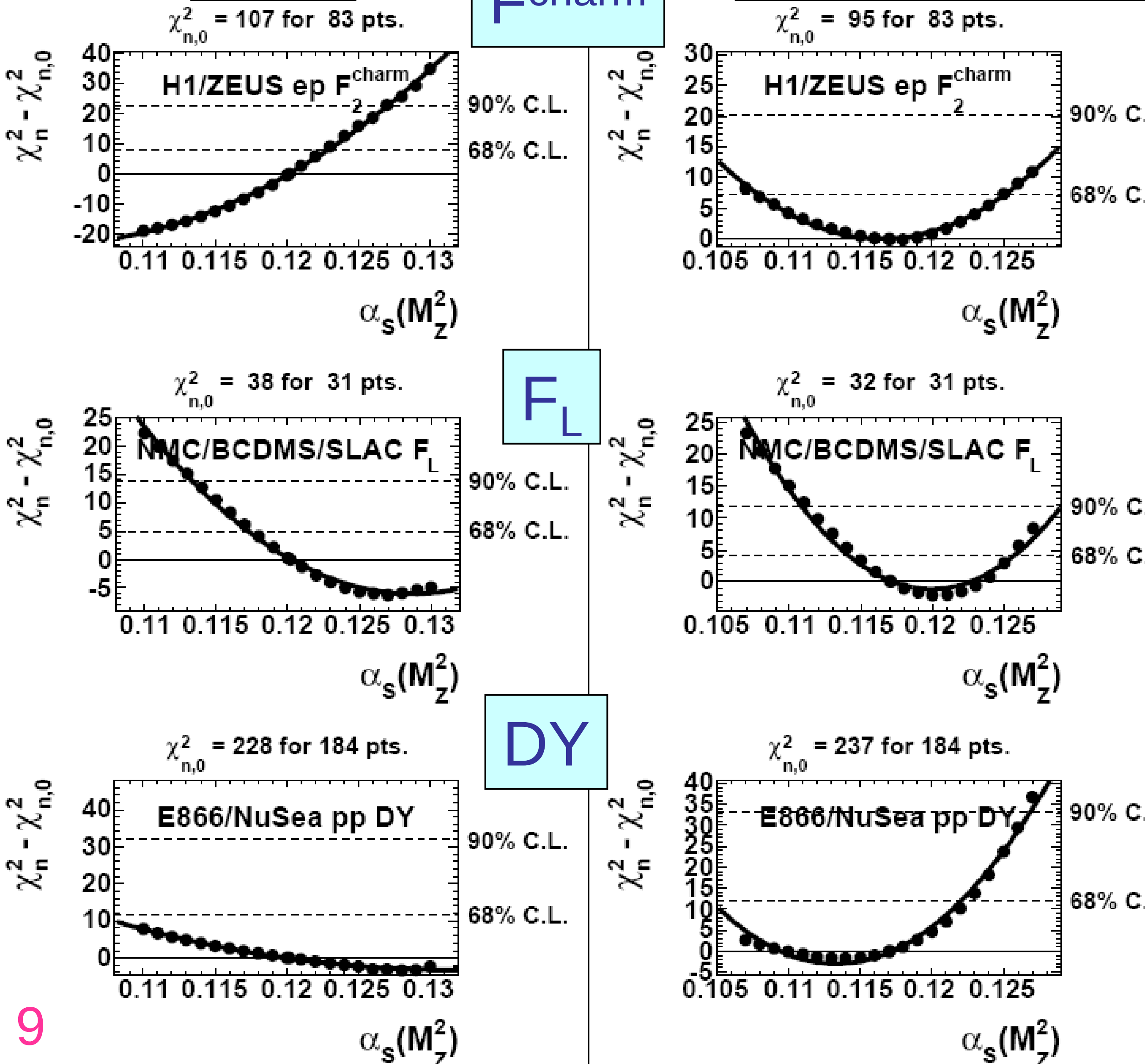
NNLO

F_2^{charm}



NLO

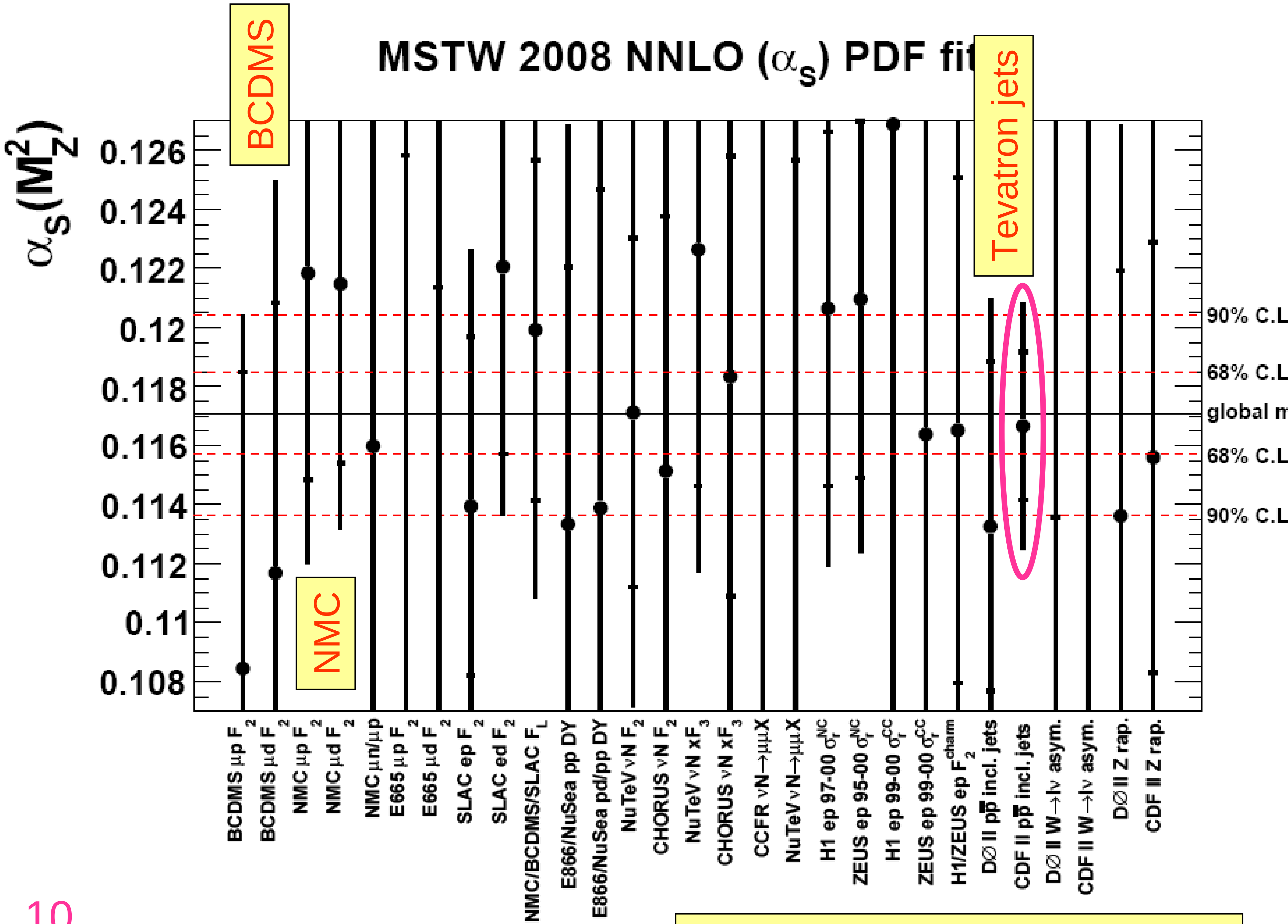
NNLO preferred



χ^2 profiles generally similar at NLO, NNLO.

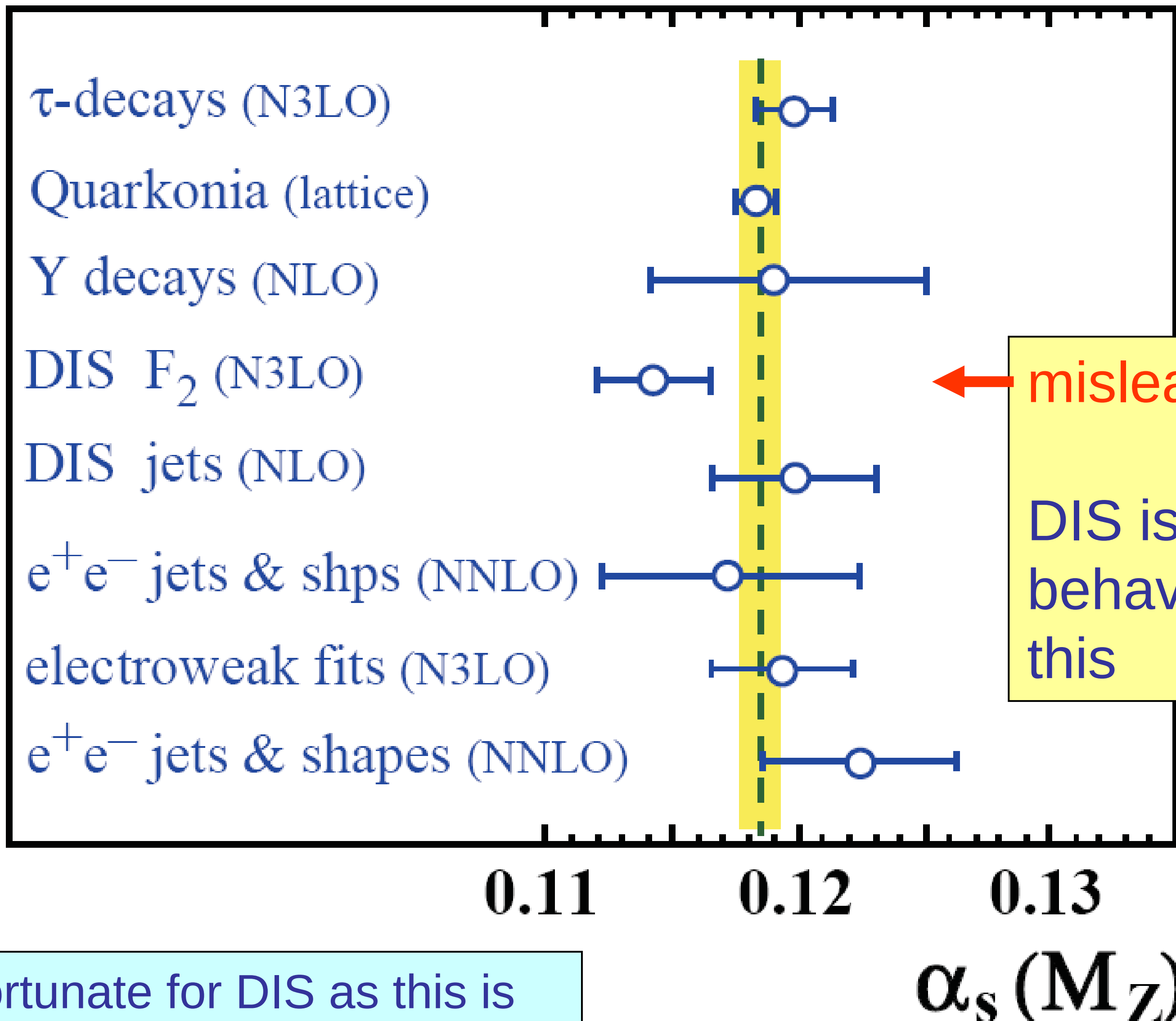
However these three prefer NNLO.

There are physical reasons for this, see MSTW α_S paper



CDF jets normalised to Z rap. distrib.

S.Bethke



misleading

DIS is better behaved than this

Unfortunate for DIS as this is taken over into Reviews of Particle Properties 2010 (PDG)

NLO	$\alpha_S(M_Z^2)$ (expt. unc. only)
MSTW (this work)	$0.1202\ ^{+0.0012}_{-0.0015}$
CTEQ [2]	0.1170 ± 0.0047
H1 [23]	0.1150 ± 0.0017
ZEUS [48]	0.1183 ± 0.0028
Alekhin [57]	0.1171 ± 0.0015
BBG [58]	0.1148 ± 0.0019
GJR [59]	0.1145 ± 0.0018

MSTW largest ?

NNLO	$\alpha_S(M_Z^2)$ (expt. unc. only)
MSTW (this work)	$0.1171\ ^{+0.0014}_{-0.0014}$
AMP [60]	0.1128 ± 0.0015
BBG [58]	$0.1134\ ^{+0.0019}_{-0.0021}$
ABKM [61]	0.1129 ± 0.0014
JR [62]	0.1158 ± 0.0035

F_2(N^3LO) → BBG [58]
non-singlet DIS
neglecting sea,
gluon for x>0.3 ?

MSTW have highest α_s from DIS fits --- why?

1. More flexible low x parametrization of gluon

   needed by data ($\Delta\chi^2 \sim 80$) --- shape confirmed by NNPDF

   without flexibility } α_s(NLO) 0.1202 → 0.1175

   α_s(NNLO) 0.1171 → 0.1157

2. Inclusion of Tevatron jet data

   Jet data themselves prefer α_s slightly lower than global α_s
   However jets demand more high x gluon (less low x gluon)
   which turn a low α_s into a better constrained high α_s

α_s ←→ gluon correlation

scaling violation: $dF/d\log Q^2 \sim \alpha_s\, g$

1.+2. → smaller gluon at low x → larger α_s

Unpublished MSTW α_s studies

(G.Watt)

MSTW2008 α_s(NNLO) = 0.117

excluding Tevatron jets = 0.117 { both jets+W asym keep α_s up

DIS only (including ν) = 0.110 { -ve high x gluon, F(charm). Avoiding this α_s=0.1155

DIS only (but excluding BCDMS) = 0.119

MSTW2008 – BCDMS = 0.118

Neither the omission, nor the inclusion, of an individual data set changes α_s by more than ~0.001 in global fit

The low y data from BCDMS could be strongly affected by a scale uncertainty of E_μ

A y>0.3 cut has been advocated, which increases α_s by 0.004 in a BCDMS – only fit

Is F_2 pure non-singlet for x>0.3 ? as in BBG

MSTW2008 χ^2 for F_2^p, F_2^d for x>0.3:

χ^2=329/282 data (BCDMS,NMC,E665,SLAC,H1,ZEUS)

160 of which are BCDMS

but χ^2=1433/282 if consider non-singlet contrib. only

In fact, contributions other than valence quarks ~ 10% at x=0.3

Indeed, at x=0.3 g(x)= u(x)/2

Low BBG α_s value due (i) to dominance of BCDMS data

(ii) neglect of singlet contributions

Note on NMC data

Alekhin,Blumlein,Moch

x<0.12 NMC extracted a Q^2 indep. R from their data to get F_2

not good

x>0.12 NMC used R from SLAC OK

ABM: NMC reduced cross section should be fitted, not F_2

Actually not a large effect for most NMC points, with only a few changing by amounts the size of the errors; so anticipate v.small effects in global fit

(we will be more consistent in future)

MSTW2008 fitted F_2 of NMC

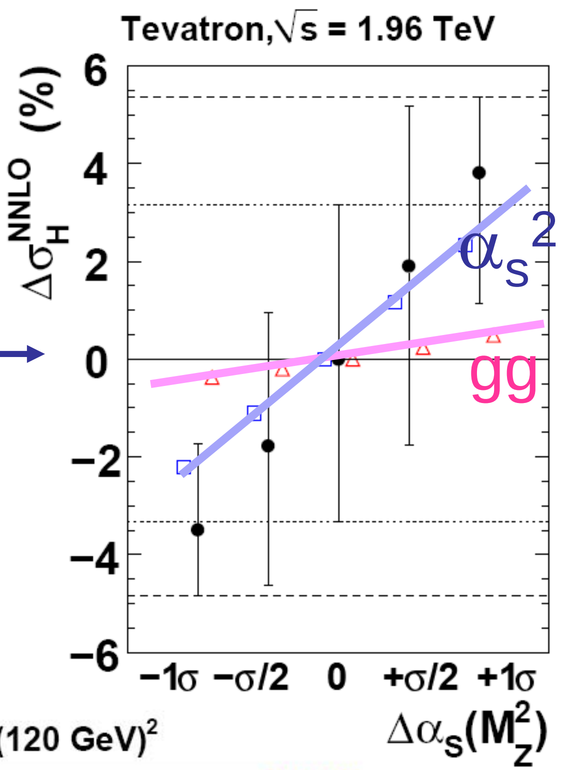
Does this bias α_s?

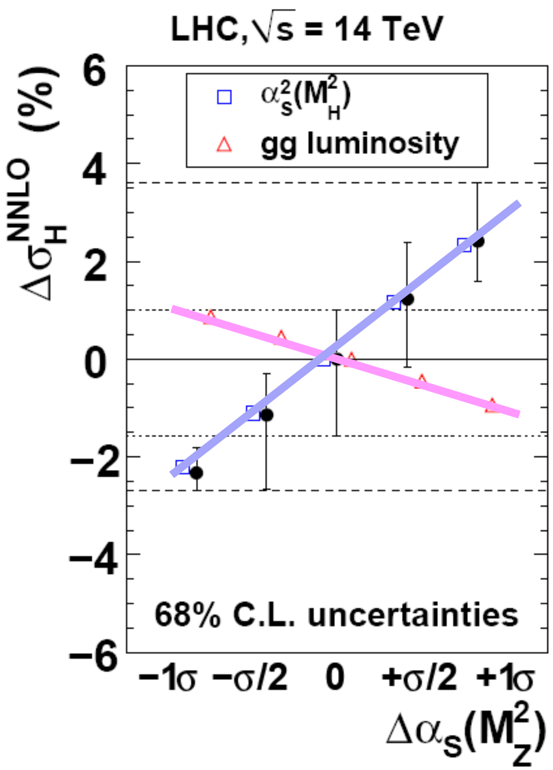
As a check, MSTW repeated global fit with NMC F_2 replaced by that obtained using R from SLAC:

α_s(NNLO) = 0.1171 → 0.1168 (v.small effect)

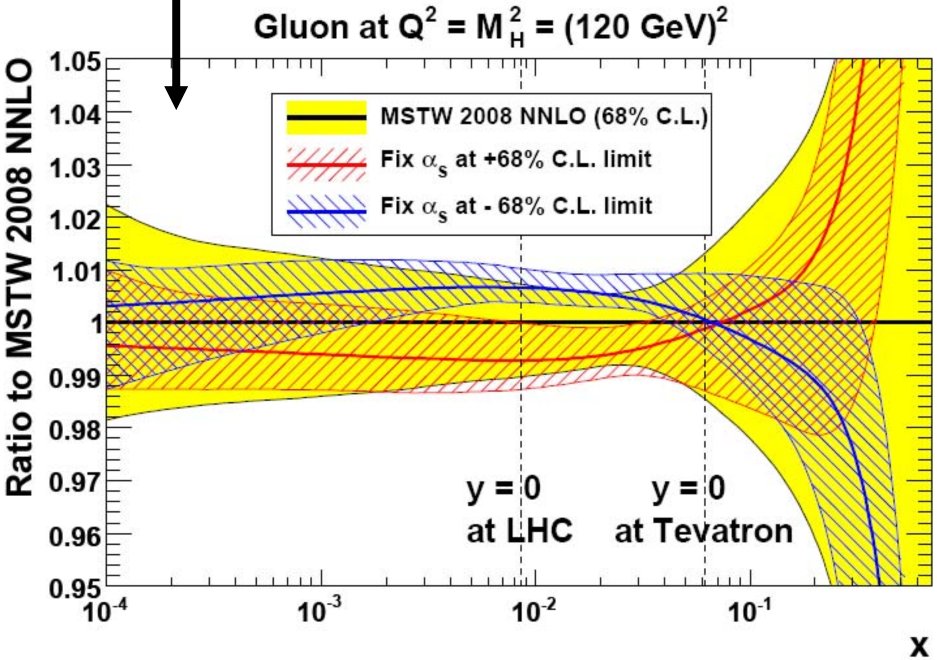
Prod. of 120 GeV Higgs by gg fusion at Tevatron and LHC

$gg * \alpha_s^2$



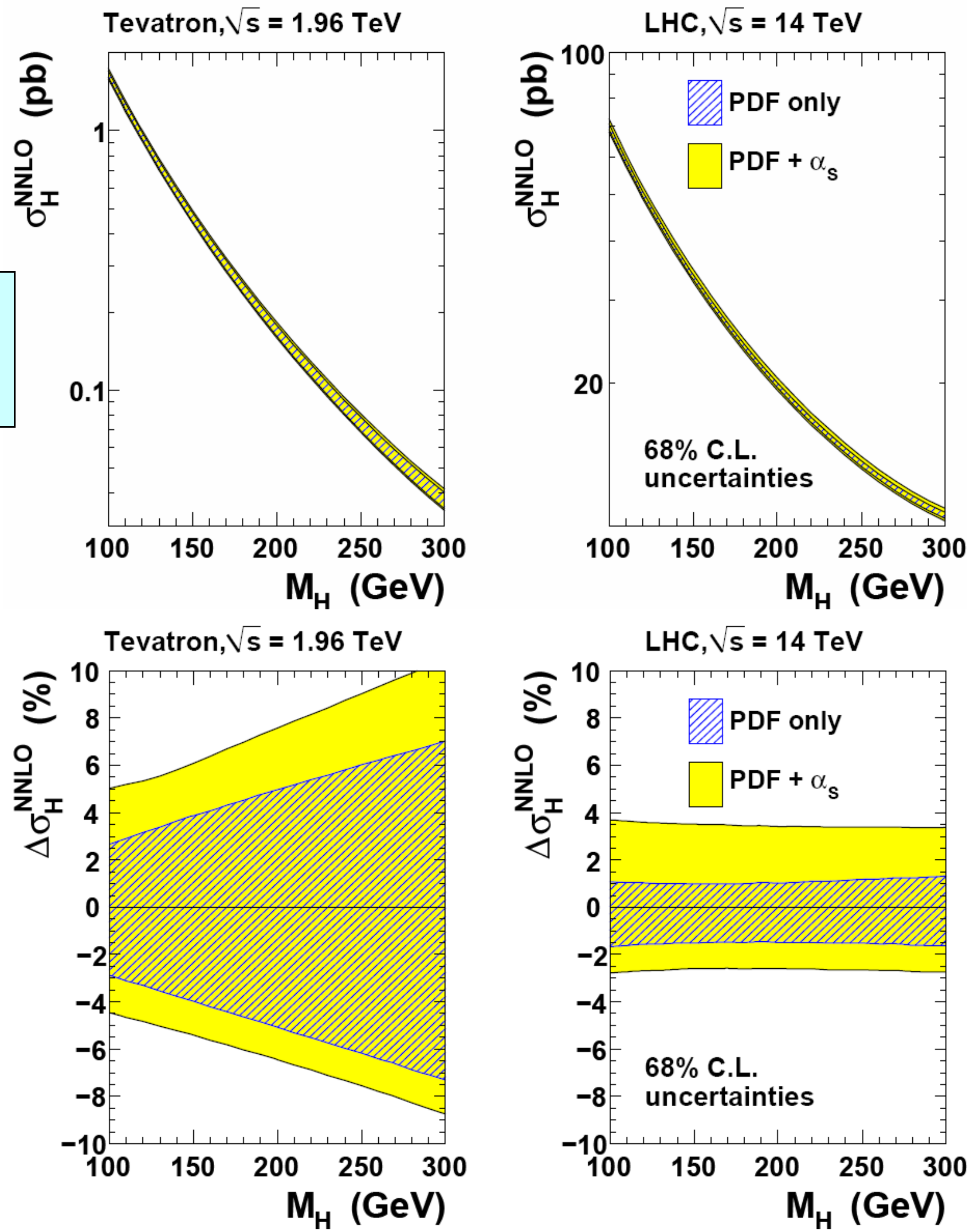


Changes of α_s change partons



PDF uncertainty enhanced when allow for PDF+α_s uncertainity

Higgs cross section at Tevatron and LHC



% uncertainty increases when allow for PDF and α_S uncertainities

Also +/-10% theory unc.

Conclusion

Graeme Watt has prepared plots of W,Z, tt(bar),H production on hepforge pdf4lhc

--- PDFs must be used with corresponding α_s

--- We studied correlations between PDF and α_s uncertainties within a global fit.

--- $\alpha_s(M_Z)$ stable to 0.001 to removal of any data set

NLO

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NNLO

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