NNPDF α_s

- PDFs & α_s
- α_s @ NLO & NNLO

RDB, Valerio Bertone, Francesco Cerutti, Luigi Del Debbio, Stefano Forte, Alberto Guffanti, Jose Latorre, S. Lionetti, Juan Rojo, Maria Ubiali
(Barcelona, Edinburgh, Copenhagen, Milan, Aachen)

St Andrews Aug 2011

Monte Carlo PDFs (eg NNPDF)

Giele & Kosower 1998

Forte & Latorre 2002

- Choose a very flexible functional form for each PDF:
  (eg a neural network: ~ 250 params)
- Generate data replicas ($\sim$ 100-1000) using exp uncertainties
- Find a good fit to each data replica by optimising χ^2
  (best fit useless – fitting statistical noise:
  instead use genetic algorithm + cross-validation)
- Treat resulting PDF replicas as statistical ensemble:
  each equally probable (importance sampling).

So simple averages give central values, uncertainties etc.

Advantages:

No theoretical bias due to parametrization

Statistically meaningful uncertainties: no need for tolerance

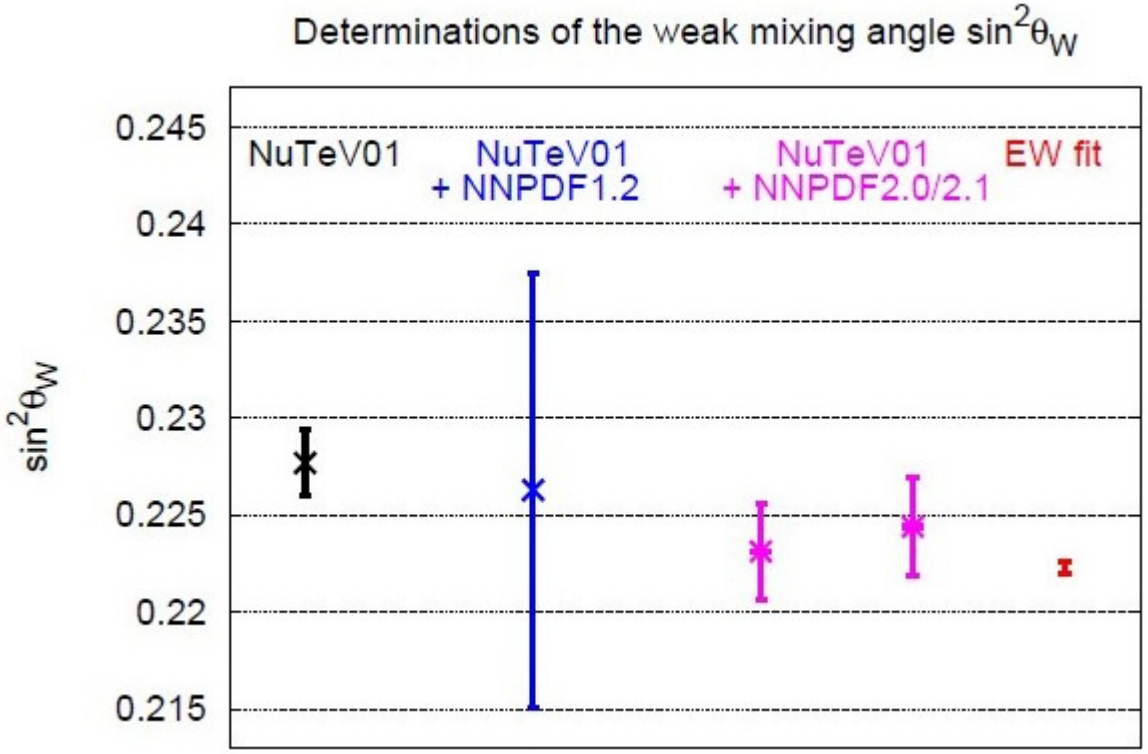
Technical stability: vary data or theory, same parametrization

The NuTeV Anomaly

arXiv:0906.1958

Determination of $\sin^2\theta_W$ using neutrino DIS data: assumed $s = \bar{s}$:

found 3-sigma discrepancy: new physics?



Include $s \neq \bar{s}$ using NNPDF1.2/2.0/2.1: discrepancy disappears!

More flexible (NN)PDFs: more precise physics!

PDFs and α_s

- $P(f|\alpha_s)$: PDFs for given α_s

  e.g. NNPDF2.1 supplied for α_s=0.114,0.115,....0.123,0.124

- $P(f) = \int P(f|\alpha_s)\, P(\alpha_s)$

  Overall PDF uncertainty: need correlation of PDFs with α_s

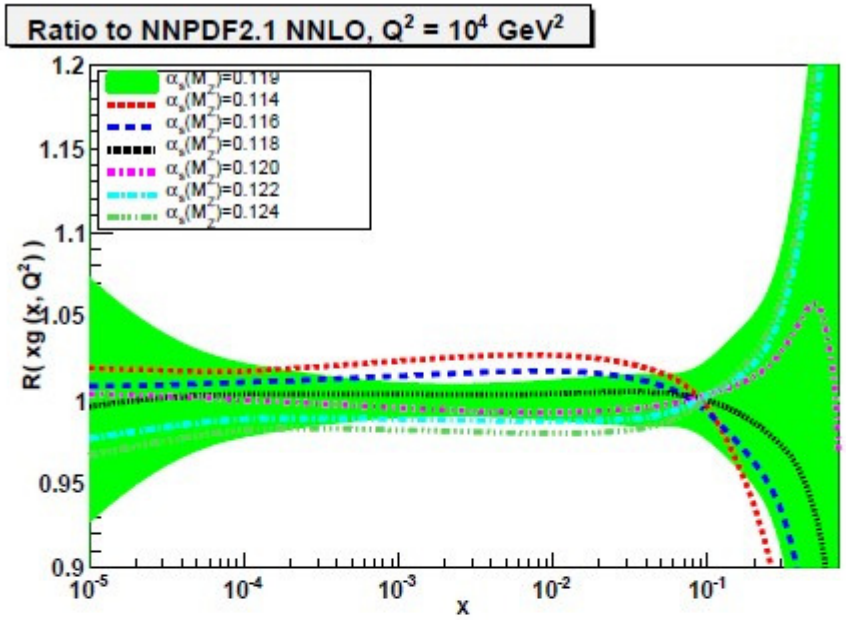
  Also prior $P(\alpha_s)$: e.g. from PDG (includes e+e- etc)

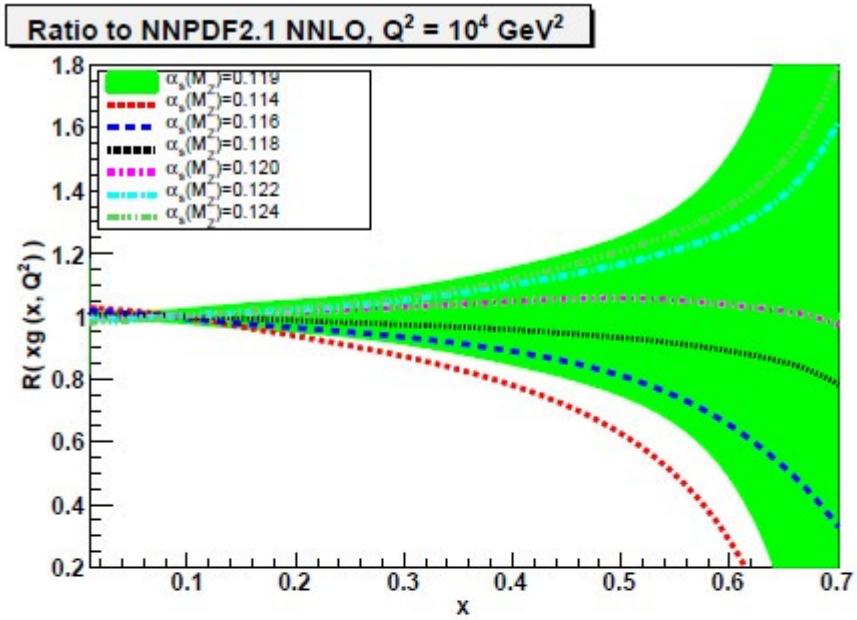
  e.g. own determination from PDF fit

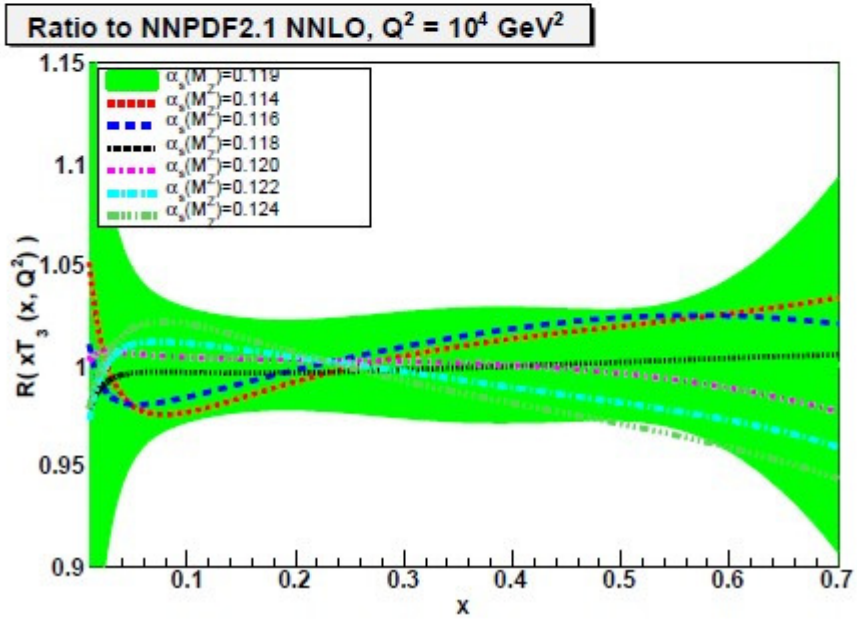
- $P(\alpha_s)$: α_s from global dataset in PDF fit

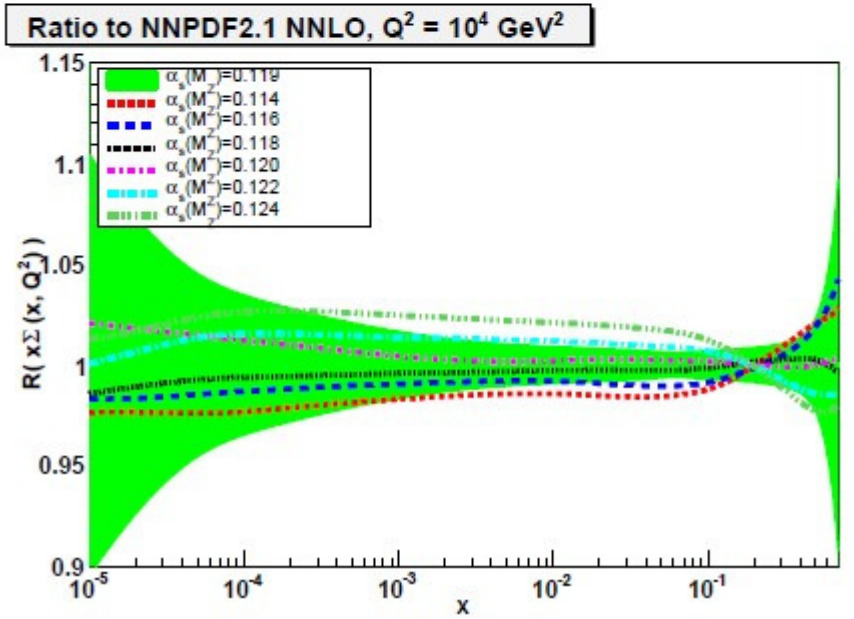
N.B. All these comments also apply to any other external parameters: m_c, m_b, \theta_W, V_{qq}, ...

PDFs vs α_s

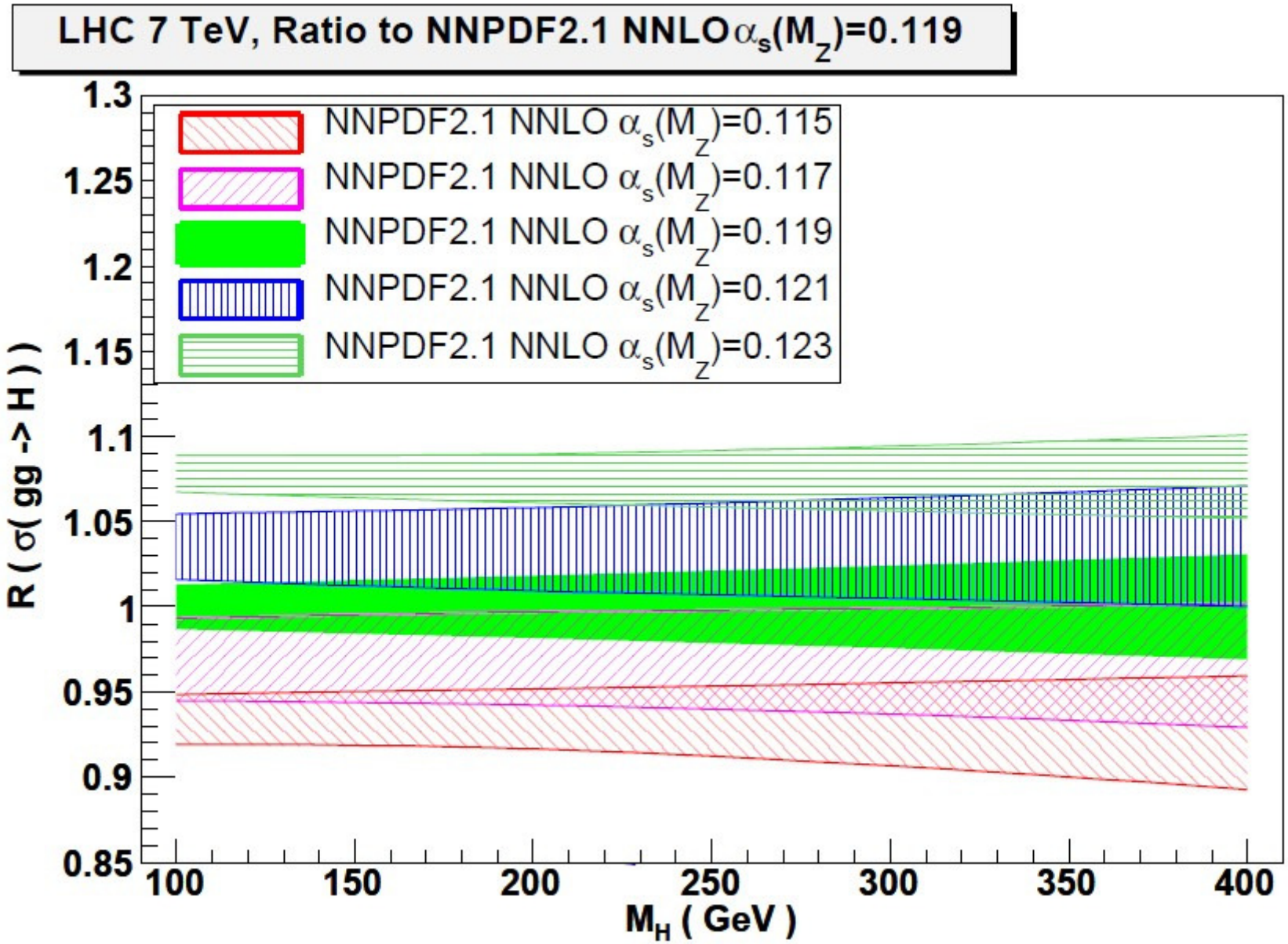




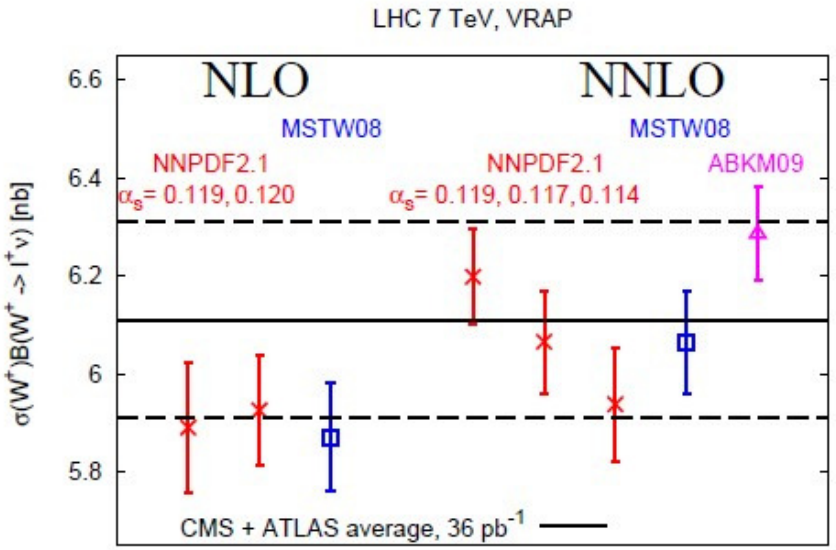


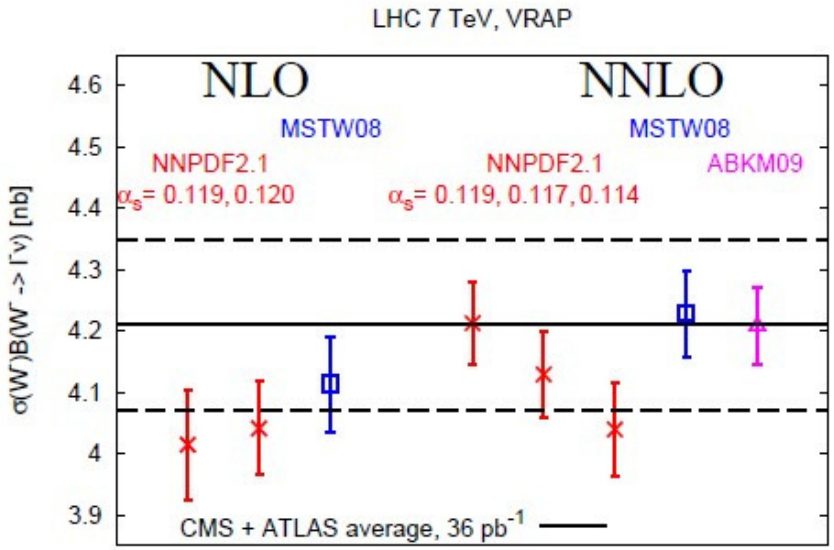


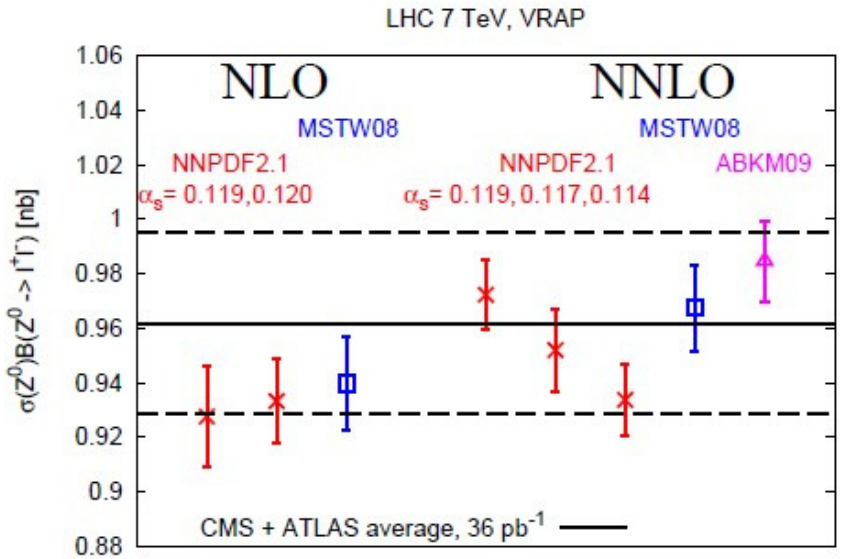
σ_{ggH} vs α_s



Meaningful comparison of PDFs requires common α_s







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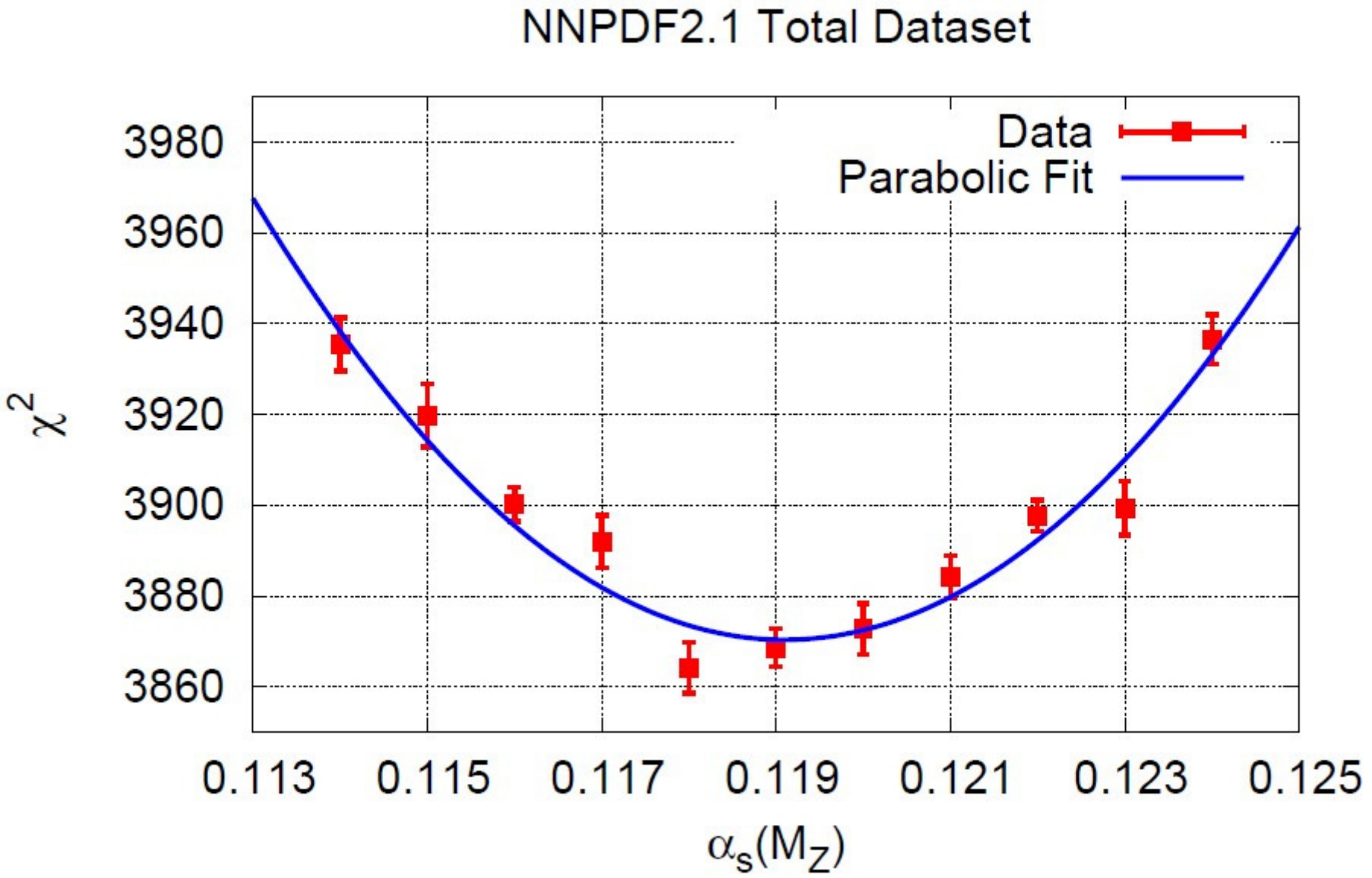
NLO

χ^2 vs α_s

arXiv:1103.2369



NLO

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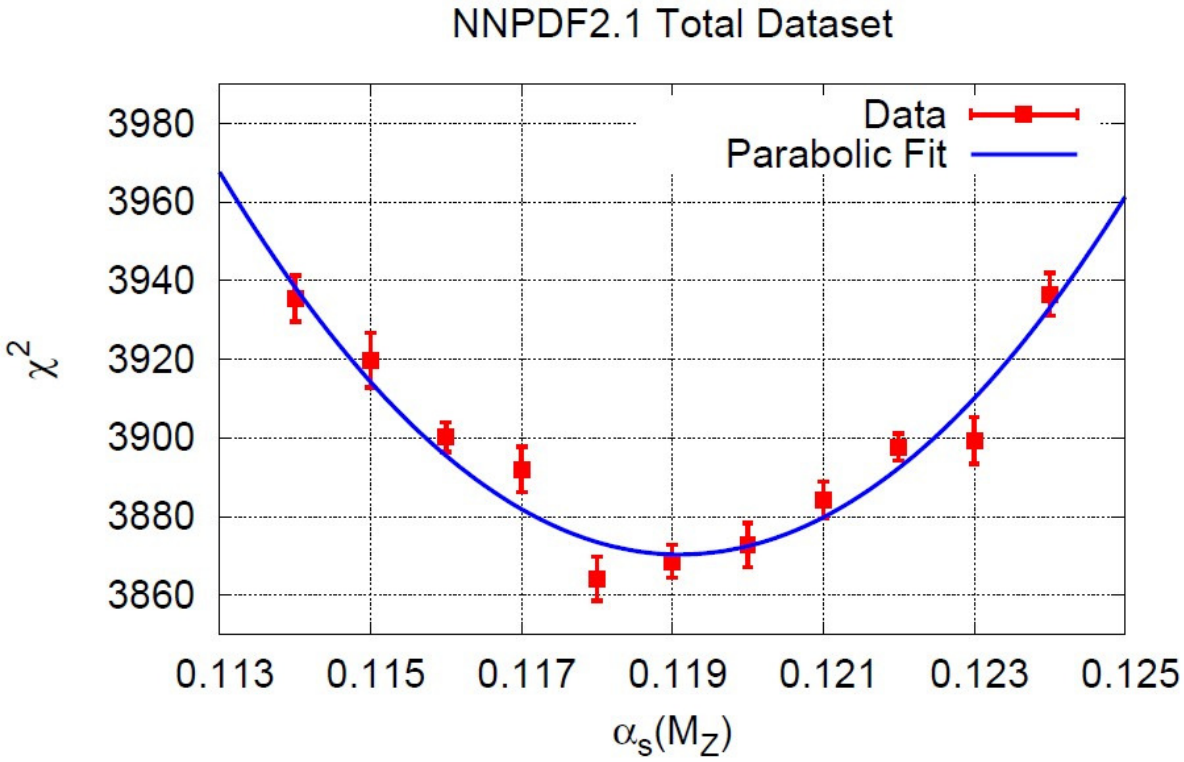
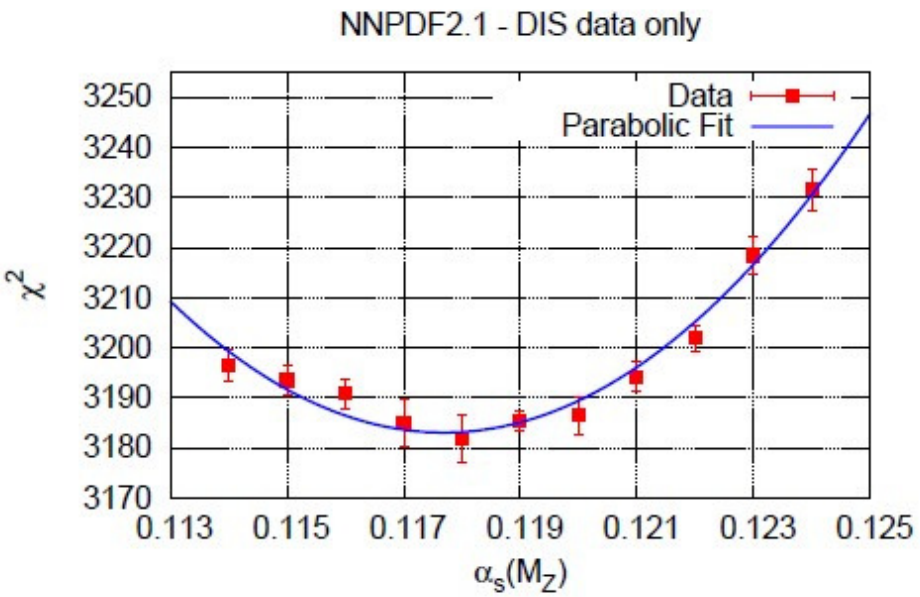
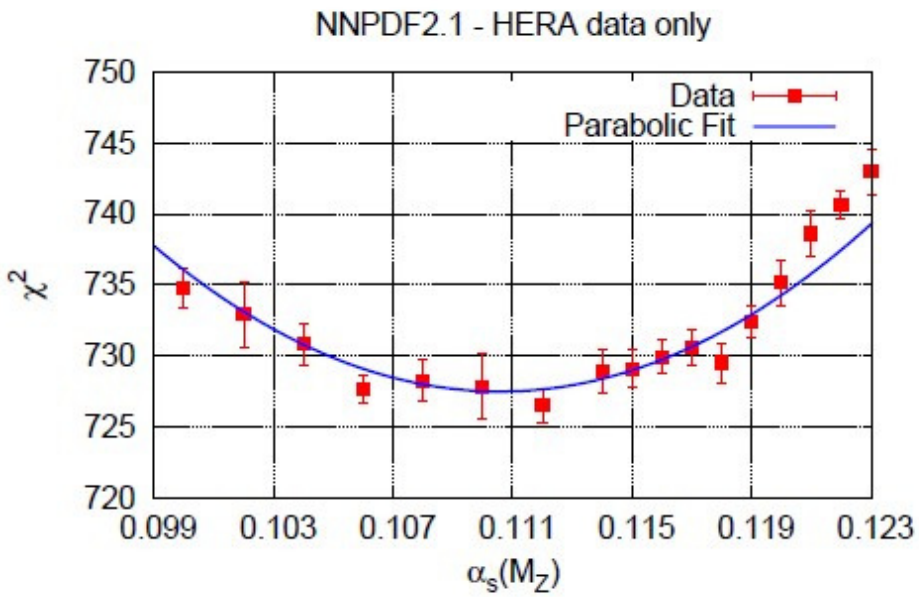
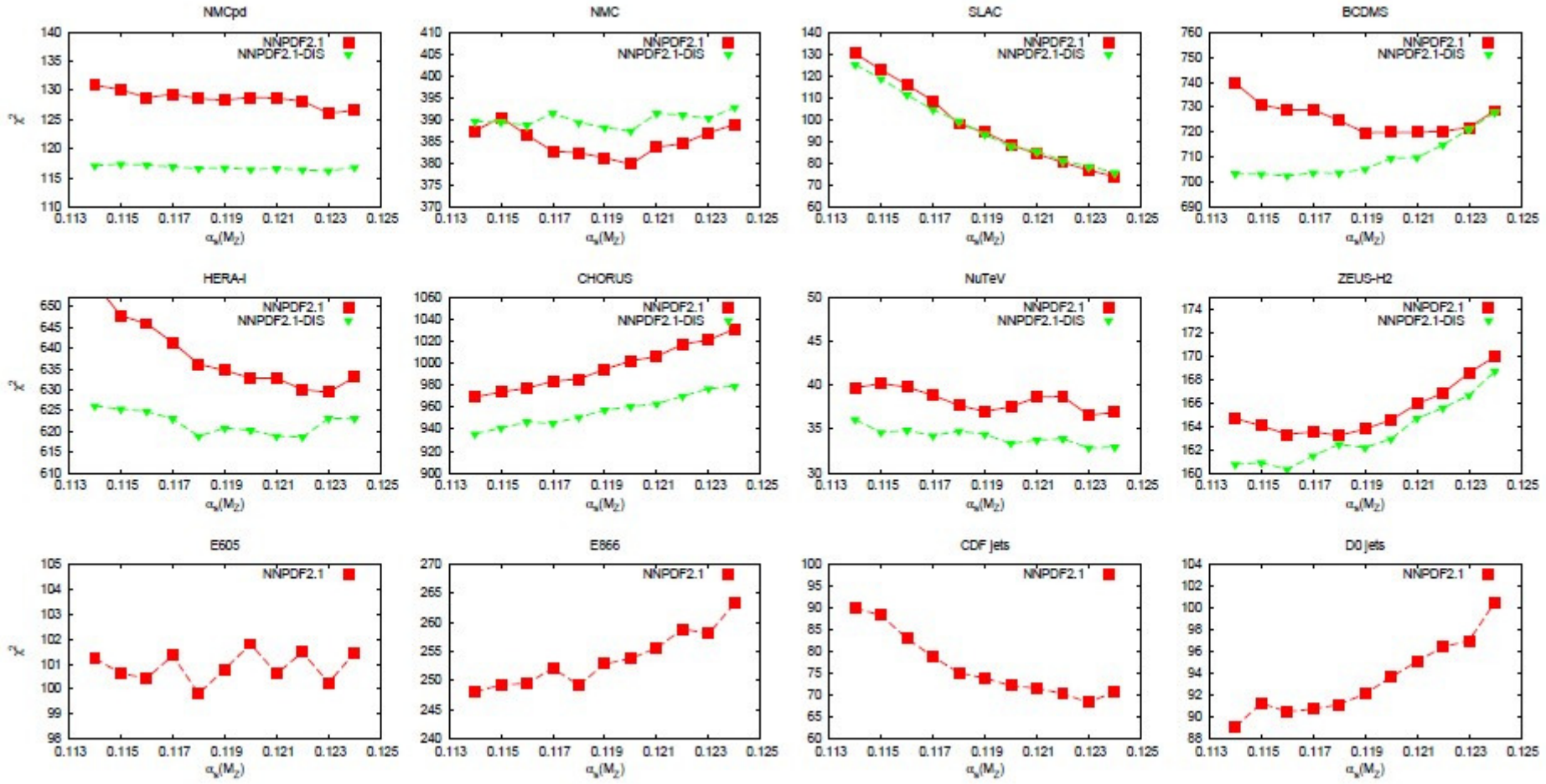






$\chi^2(\alpha_s)$ for individual datasets

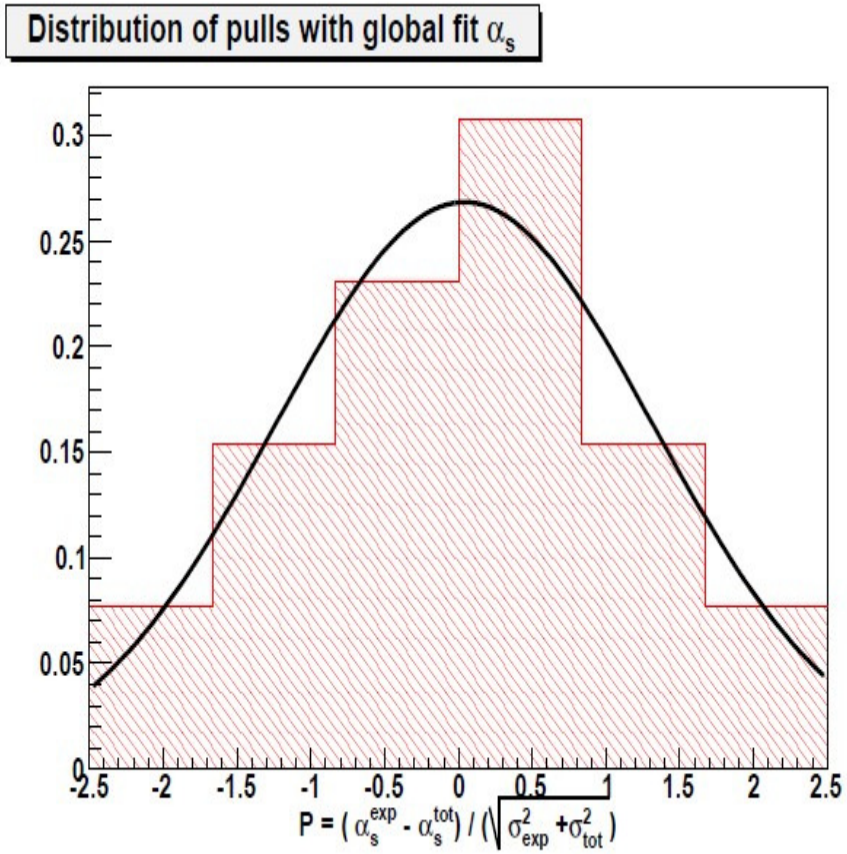


N.B. no min in BCDMS for DIS-only

Pulls:

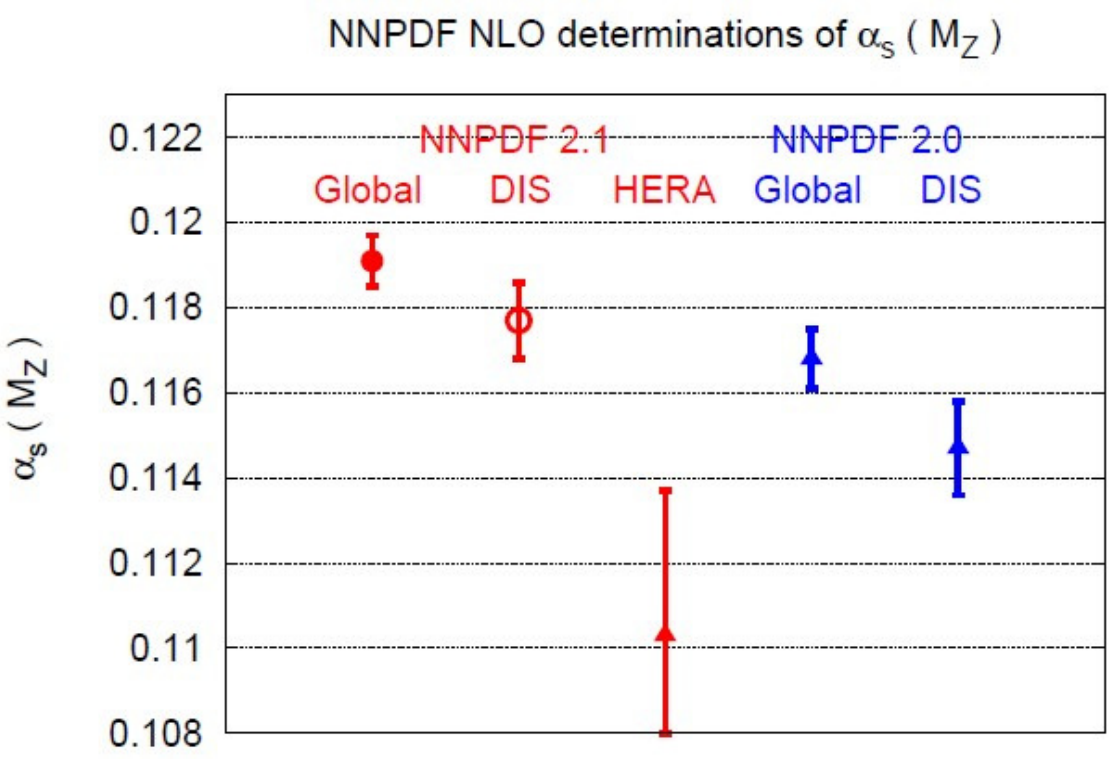
$$P_i \equiv \frac{\alpha_s^i\left(M_Z\right) - \alpha_s^{\mathrm{tot}}\left(M_Z\right)}{\sqrt{\sigma_{\alpha_s}^{i,2} + \sigma_{\alpha_s}^{\mathrm{tot},2}}}$$

Experiment	$\alpha_s^i \pm \sigma_{\alpha_s}^i$	P_i
NMCp	0.1192 ± 0.0018	-0.05
BCDMS	0.1204 ± 0.0015	-0.78
HERA-I	0.1223 ± 0.0018	-1.65
ZEUS-H2	0.1170 ± 0.0027	0.75
NuTeV	0.1252 ± 0.0068	-0.89
ZEUSF2C	0.1144 ± 0.0060	0.77
E605	0.1168 ± 0.0100	0.22
E866	0.1135 ± 0.0029	1.87
CDFWASY	0.1181 ± 0.006	0.16
CDFZRAP	0.1150 ± 0.0034	1.18
D0ZRAP	0.1227 ± 0.0067	-0.53
CDFR2KT	0.1228 ± 0.0021	-1.67
D0R2CON	0.1141 ± 0.0031	1.57



Results (NLO)

	$\alpha_s(M_Z)$	$\chi^2_{\rm par}/N_{\rm dof}$
NNPDF2.1	$0.1191 \pm 0.0006^{\rm exp} \pm 0.0001^{\rm proc}$	1.6
NNPDF2.1 DIS–only	$0.1178 \pm 0.0009^{\rm exp} \pm 0.0002^{\rm proc}$	0.8
NNPDF2.1 HERA–only	$0.1101 \pm 0.0033^{\rm exp} \pm 0.0003^{\rm proc}$	1.1
NNPDF2.0	$0.1168 \pm 0.0007^{\rm exp} \pm 0.0001^{\rm proc}$	0.4
NNPDF2.0 DIS–only	$0.1145 \pm 0.0010^{\rm exp} \pm 0.0003^{\rm proc}$	1.4.



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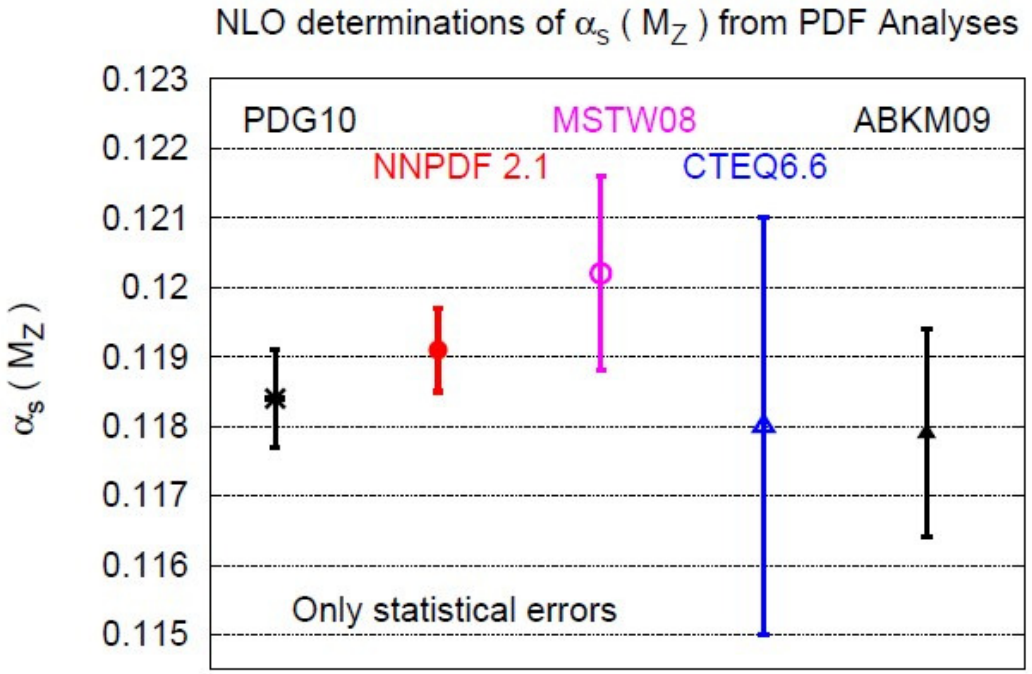
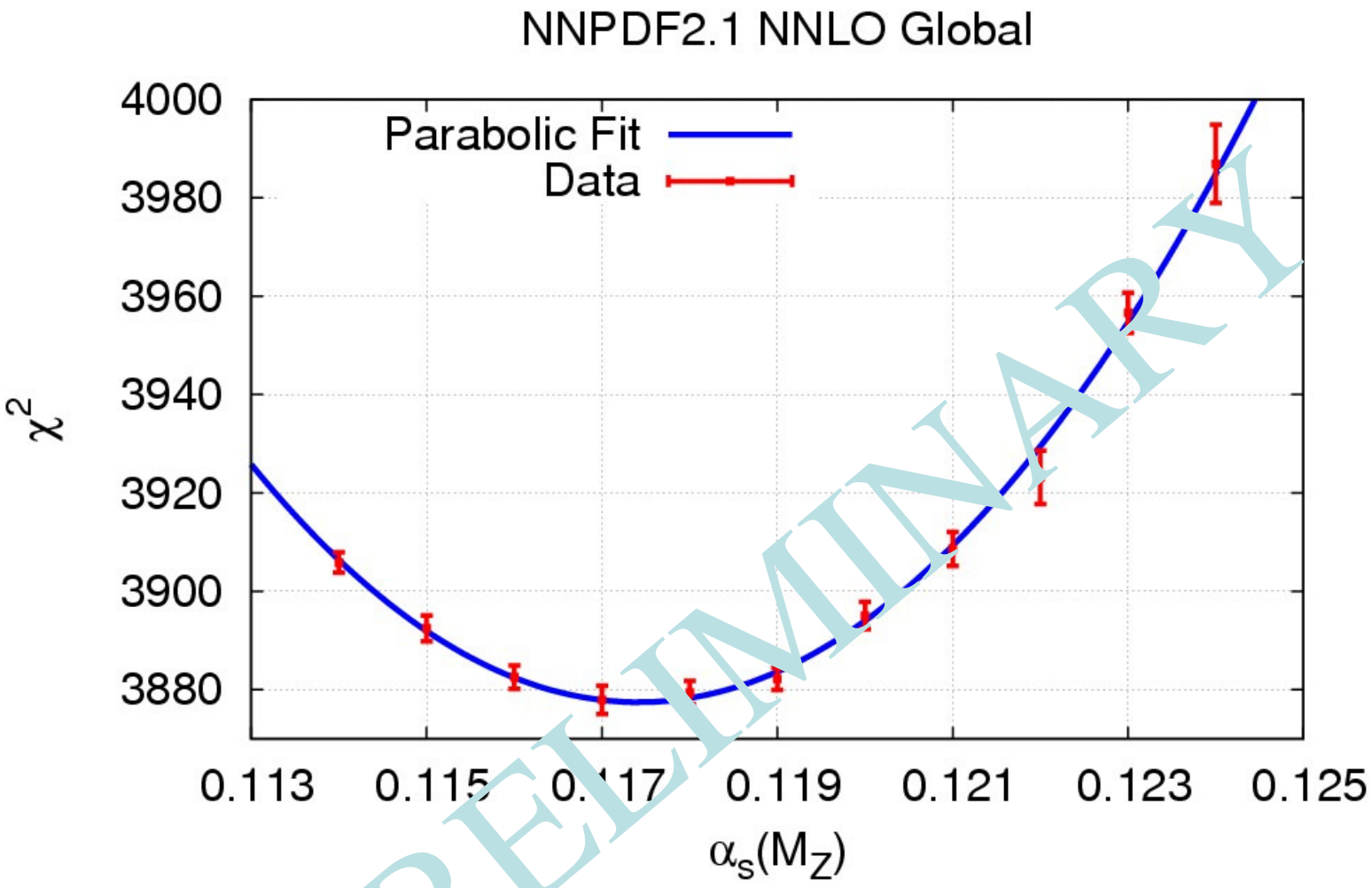
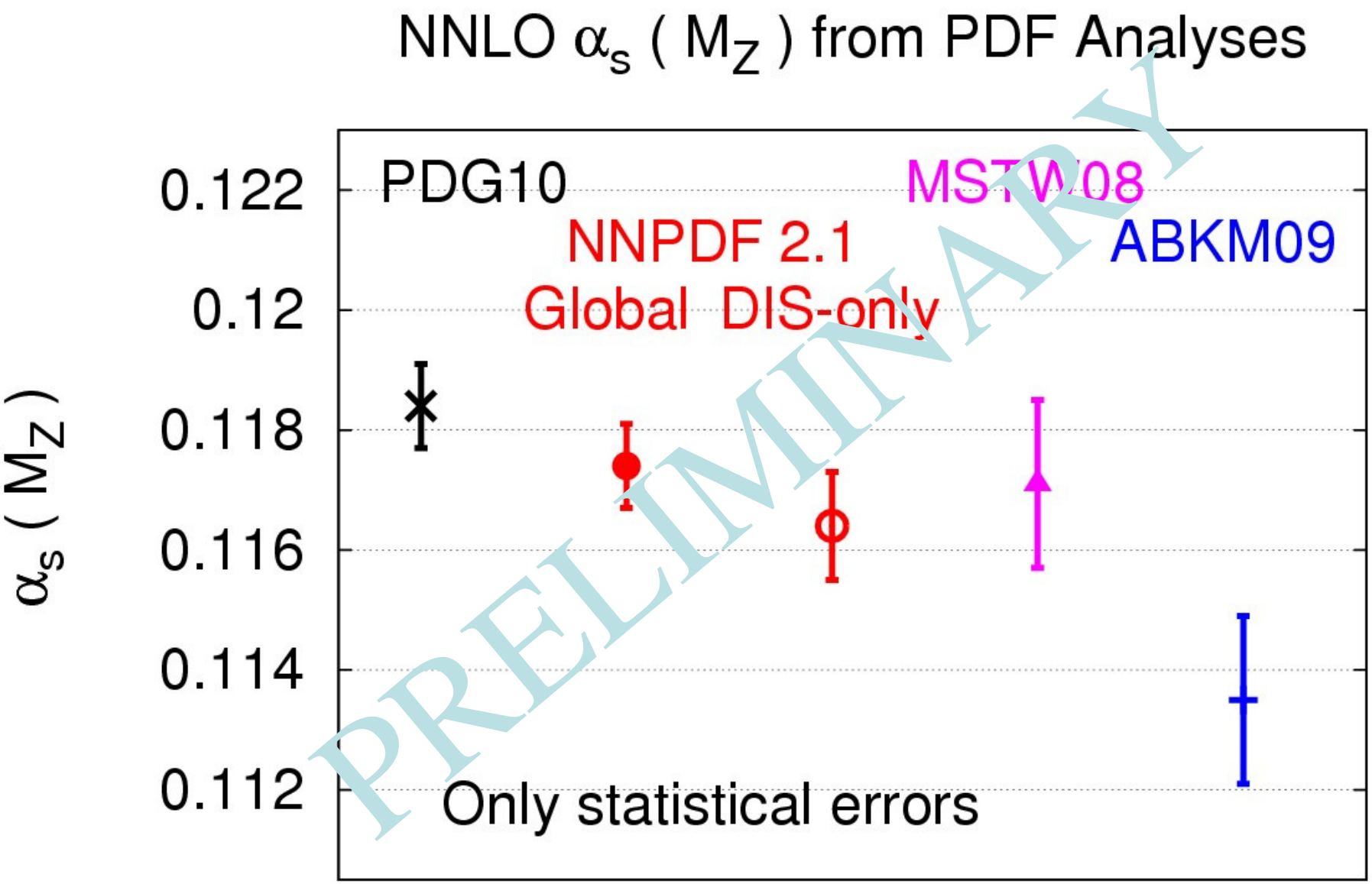


More flexible (NN)PDFs: more precise physics!



	$\alpha_s\,(M_Z)$	$\chi^2_{\rm par}/N_{\rm dof}$
NNPDF2.1 NNLO	$0.1174 \pm 0.0006^{\rm exp} \pm 0.0001^{\rm proc}$	0.6
NNPDF2.1 NNLO DIS-only	$0.1164 \pm 0.0009^{\rm exp} \pm 0.0002^{\rm proc}$	1.1


NNLO α_s (M_Z) from PDF Analyses
α_s (M_Z)
0.122
0.12
0.118
0.116
0.114
0.112
PDG10
NNPDF 2.1
Global
DIS-only
MSTW08
ABKM09
Only statistical errors
PRELIMINARY

Summary & Outlook

NLO: $\alpha_s = 0.1191 \pm 0.0006$

NNLO: $\alpha_s = 0.1174 \pm 0.0006$

Theory uncertainty: ~ 0.0017 (conservative?)