ABM update and comparisons

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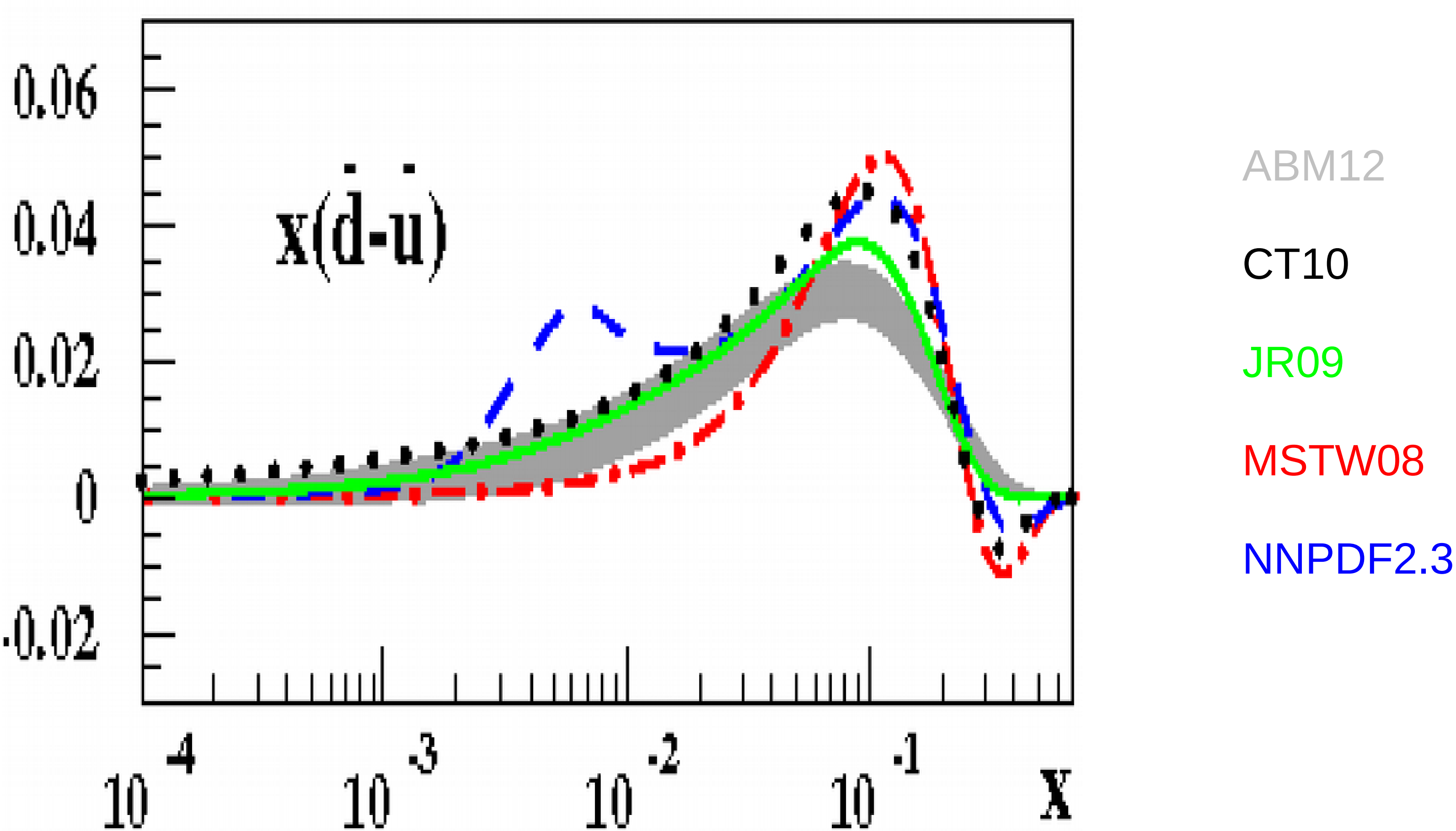
sa, Blümlein, Moch, Plačakytė hep-ph/1508.07923

PDF4LHC, CERN, 27 Oct 2015

Sea quark iso-spin asymmetry



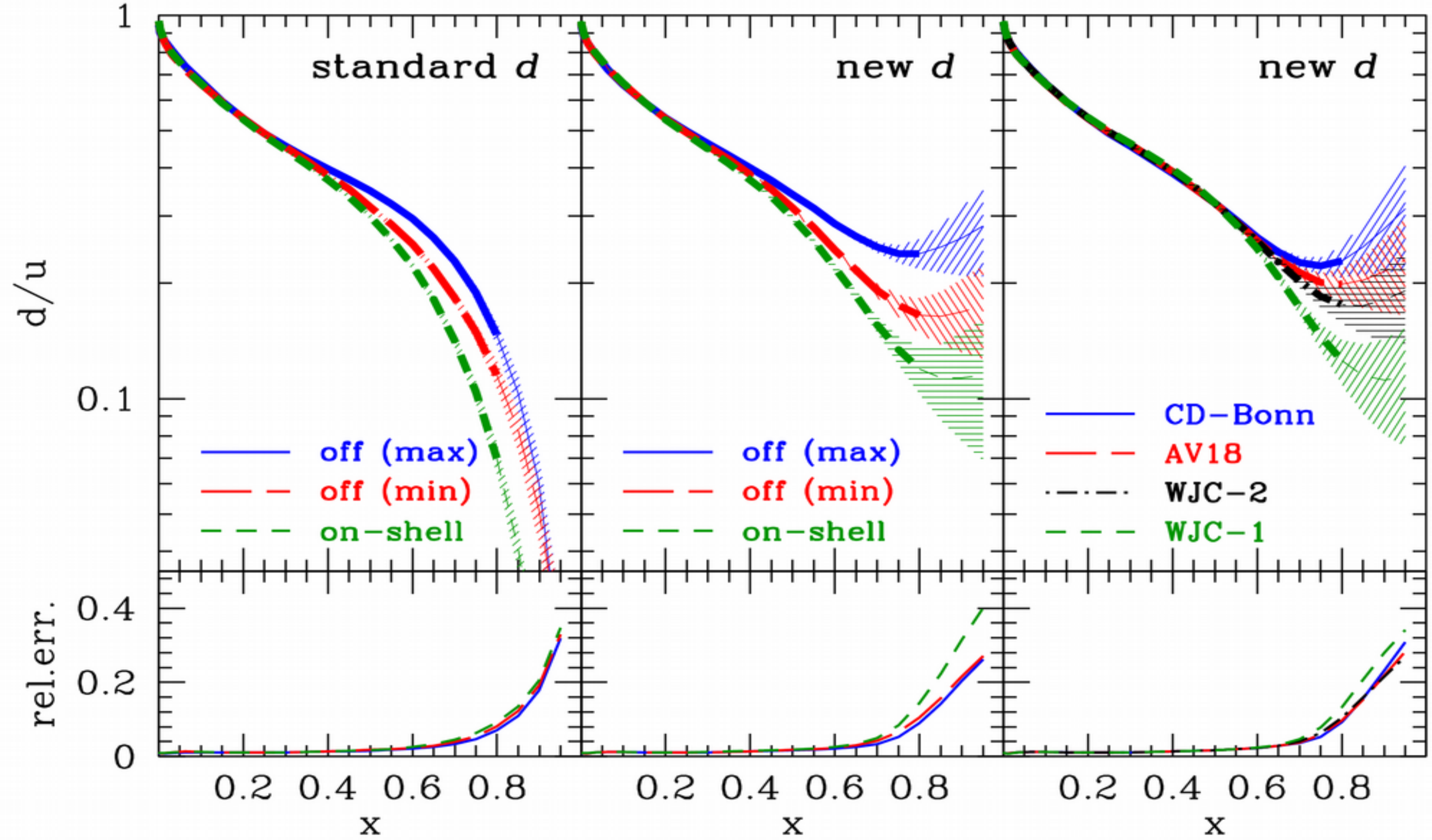
sa, Blümlein, Moch PRD 89, 054028 (2014)

- At x~0.1 the sea quark iso-spin asymmetry is controlled by the fixed-target DY data (E-866), weak constraint from the DIS (NMC)

- At x<0.01 Regge-like constraint like $x^{(a-1)}$, with a close to the meson trajectory intercept; the “unbiased” NNPDF fit follows the same trend

Onset of the Regge asymptotics is out of control

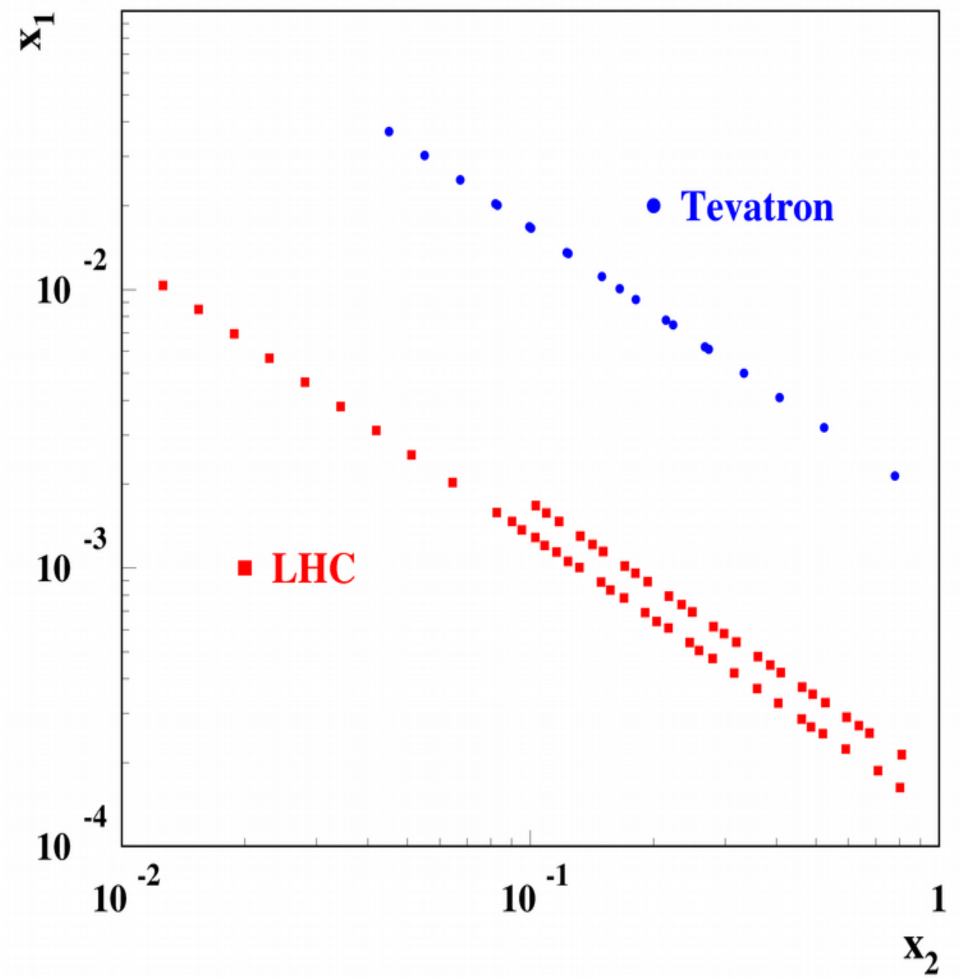
d/u ratio at large x



Accarti et al. PRD 84, 014008 (2011)

d/u ratio extracted from the DIS data is quite sensitive to the details of modeling nuclear effects in deuterium

LO kinematics of the recent W&Z data



In the forward region $x_2 >> x_1$

$\sigma(W^+) \sim u(x_2)\ \mathrm{dbar}\ (x_1)$

$\sigma(W^-) \sim d(x_2)\ \mathrm{ubar}(x_1)$

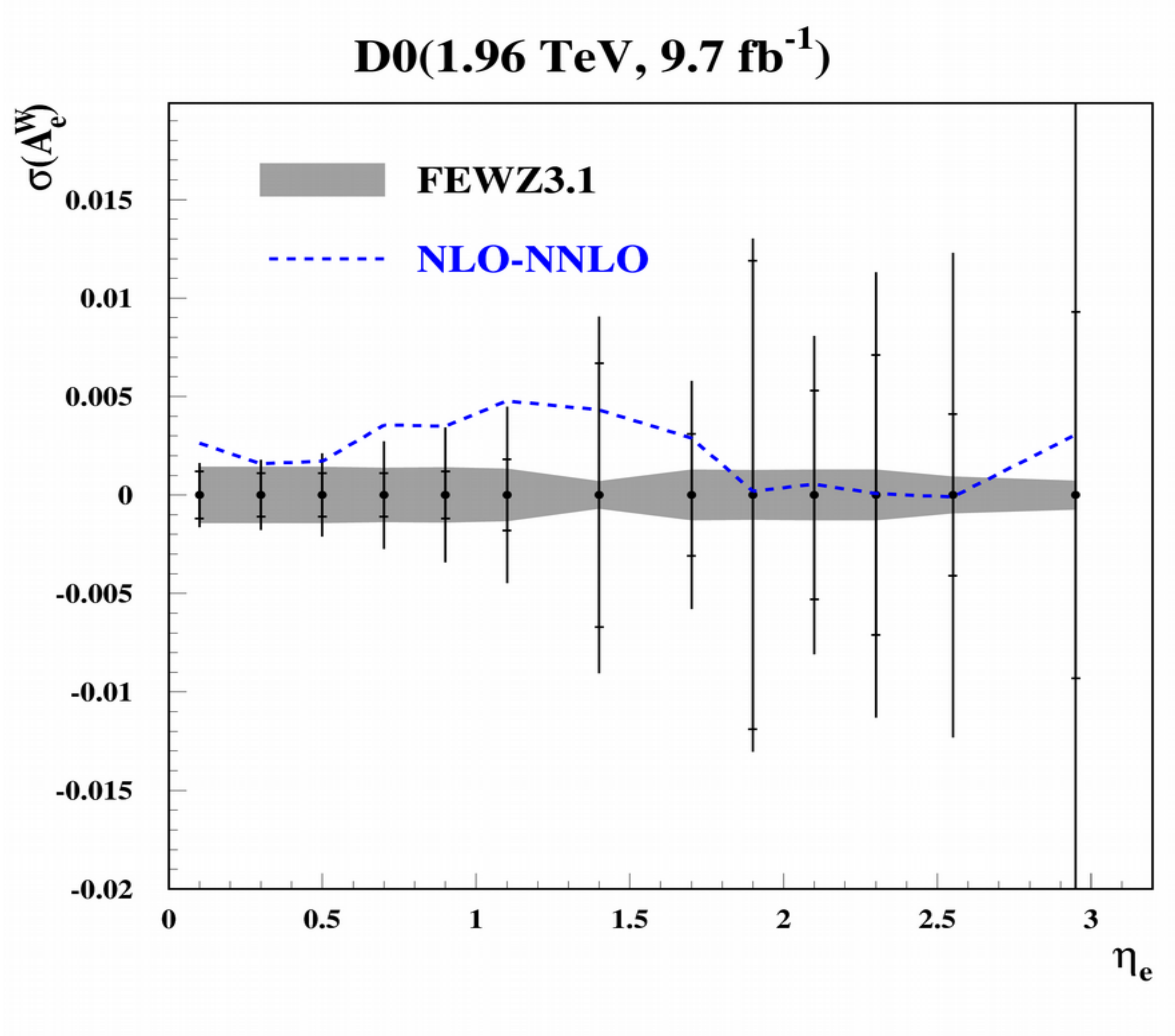
$\sigma(Z) \sim Q_U^2 u(x_2)\ \mathrm{ubar}\ (x_1) + Q_D^2 d(x_2)\ \mathrm{dbar}(x_1)$

$\sigma(DIS) \sim q_u^2 u(x_2) + q_d^2 d(x_2)$

Forward W&Z production probes small/large x and is complementary to the DIS → constraint on the quark iso-spin asymmetry

Experiment	ATLAS	CMS	D0		LHCb	
$\sqrt{s}$ (TeV)	7	7	1.96		7	8
Final states	$W^+ \to l^+\nu$ $W^- \to l^-\nu$ $Z \to l^+l^-$	$W^+ \to \mu^+\nu$ $W^- \to \mu^-\nu$	$W^+ \to \mu^+\nu$ $W^- \to \mu^-\nu$	$W^+ \to e^+\nu$ $W^- \to e^-\nu$	$W^+ \to \mu^+\nu$ $W^- \to \mu^-\nu$ $Z \to \mu^+\mu^-$	$Z \to e^+e^-$
Reference	[23]	[1]	[3]	[4]	[18]	[19]
Cut on the lepton P_T	$P_T^l > 20$ GeV	$P_T^\mu > 25$ GeV	$P_T^\mu > 25$ GeV	$P_T^e > 25$ GeV	$P_T^\mu > 20$ GeV	$P_T^e > 20$ GeV
Luminosity (1/fb)	0.035	4.7	7.3	9.7	1.	2.
NDP	30	11	10	13	31	17

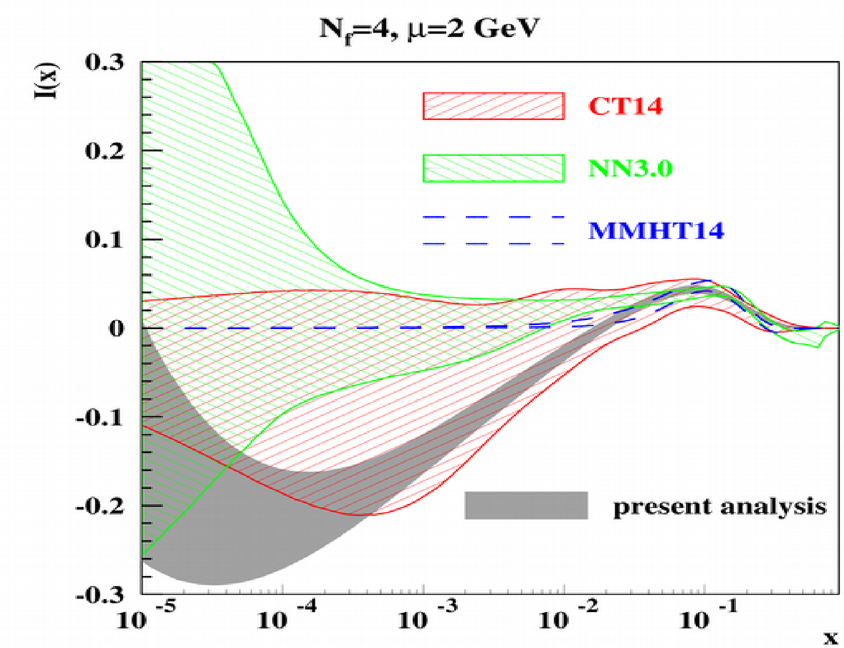
Computation accuracy



- Accuracy of O(1 ppm) is required to meet uncertainties in the experimental data → O(10^4 h) of running FEWZ 3.1 in NNLO

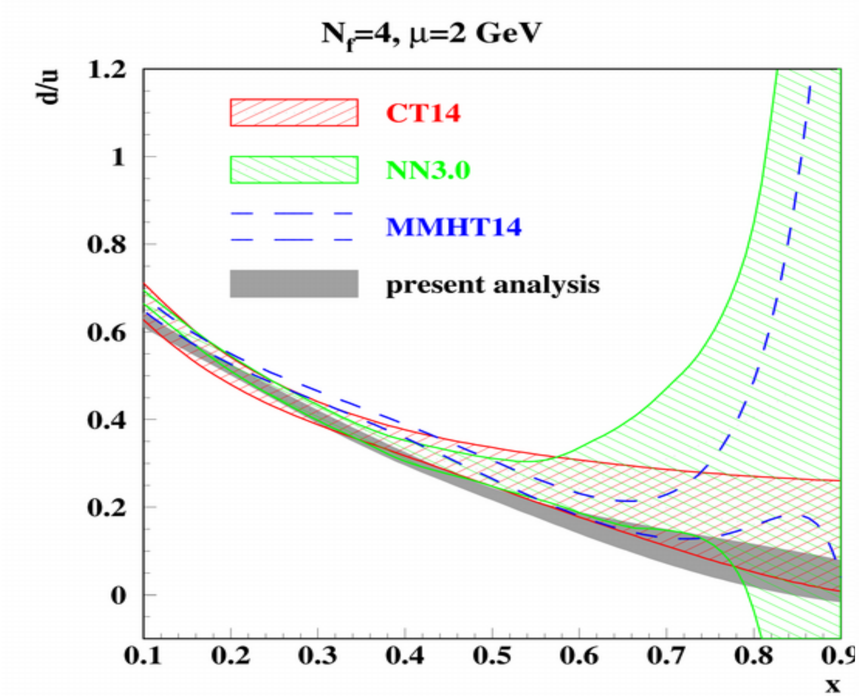
- An interpolation grid a la FASTNLO is used (cf. Extras)

ABM fit with recent Drell-Yan data



- Relaxed form of the sea iso-spin asymmetry at small x; Regge-like behaviour is reproduced only at x~10^{-6}; at large x it is still defined by the phase-space constraint

- Good constraint on the d/u ratio w/o deuteron data; big spread between different PDF sets: up to factor of 30 at large x → PDF4LHC recommendations are misleading in this part



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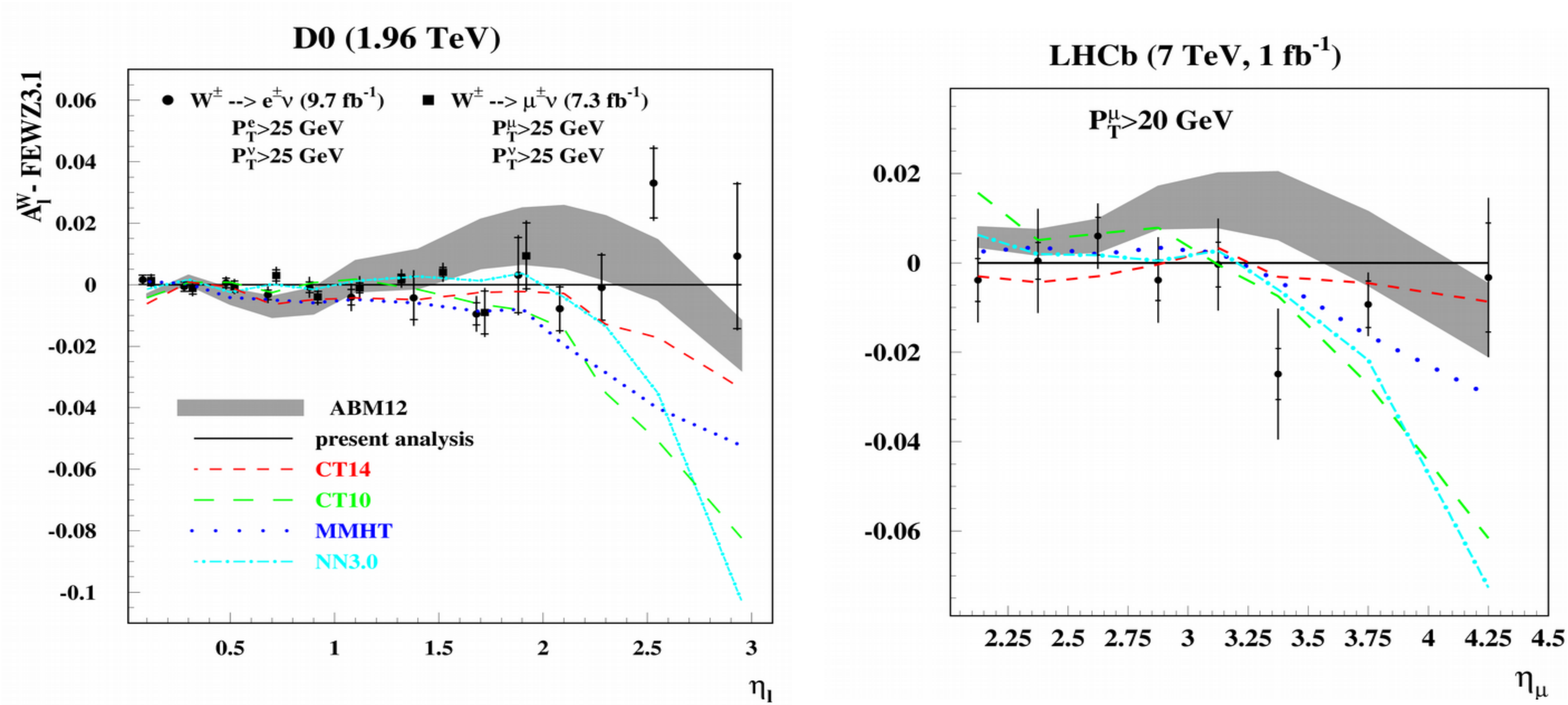
	Reference	[23]	[1]	[3]	[4]	[18]	[19]
	NDP	30	11	10	13	31	17
χ^2	this work	29.8	22.5	16.9	18.0	44.1	18.2
	this work^a	32.3	19.5(13.5^b)	13.5	9.5	34.7	19.1
	ABM12 [8]	34.5	–	–	–	–	–
	CT14 [10]	42	–^{c}	–	34.7	–	–
	HERAFitter [13]	–	–	13	19	–	–
	MMHT14 [11]	39	–	21	–	–	–
	NN3.0 [12]	35.4	18.9	–	–	–	–

^{a}The variants with all collider DY and $W^\pm$-boson data excluded except the one given.
^{b}The value obtained assuming systematic uncertainties to be uncorrelated.
^{c}Statistically less significant data with the cut of $P_T^\mu > 35$ GeV are used.

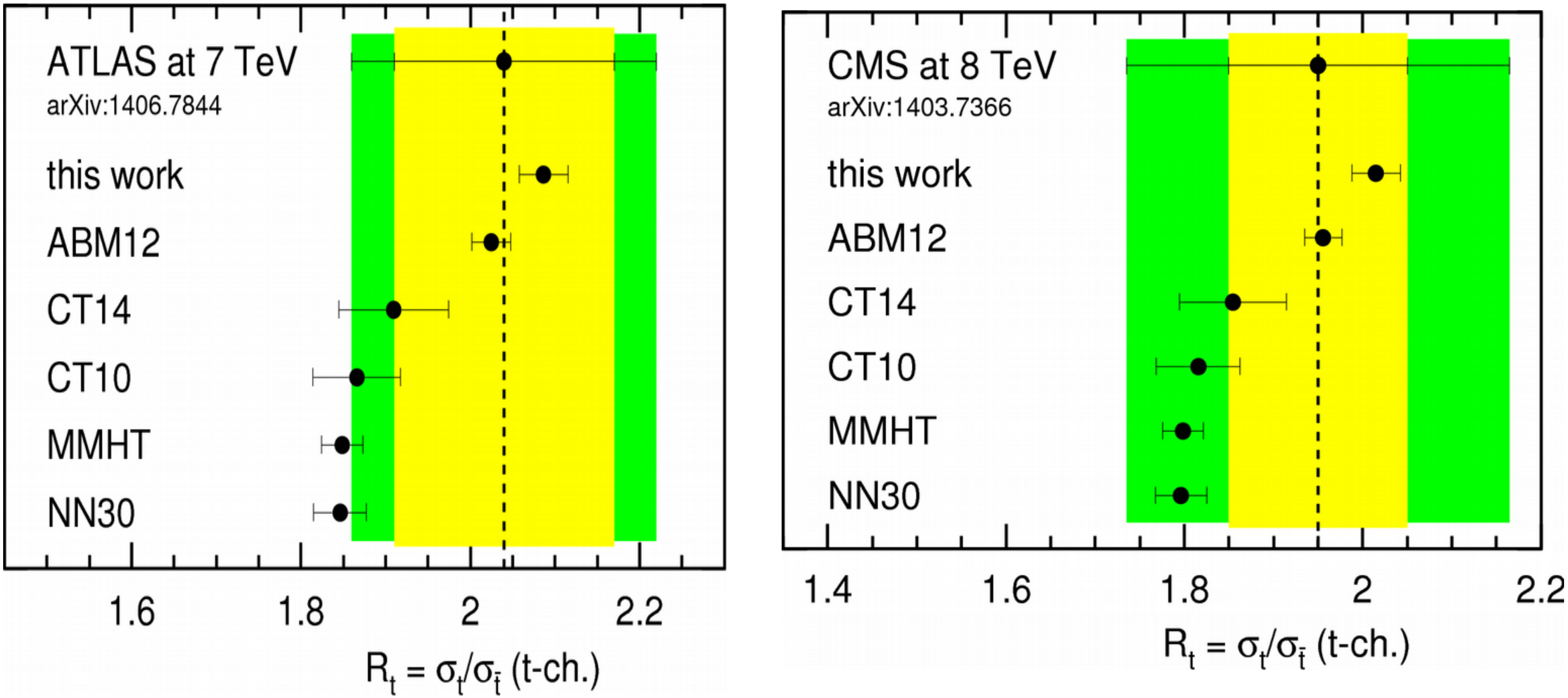
DY at large rapidity



- The data can be evidently used for consolidation of the PDFs, however, unification of the theoretical accuracy is also needed

ABM	CT	MMHT	NNPDF
Interpolation of accurate NNLO grid (a'la FASTNLO)	NNLL (ResBos)	NLO + NNLO K-factor	NLO + NNLO C-factors (y-dependent K-factors)

Implication for the single-top production

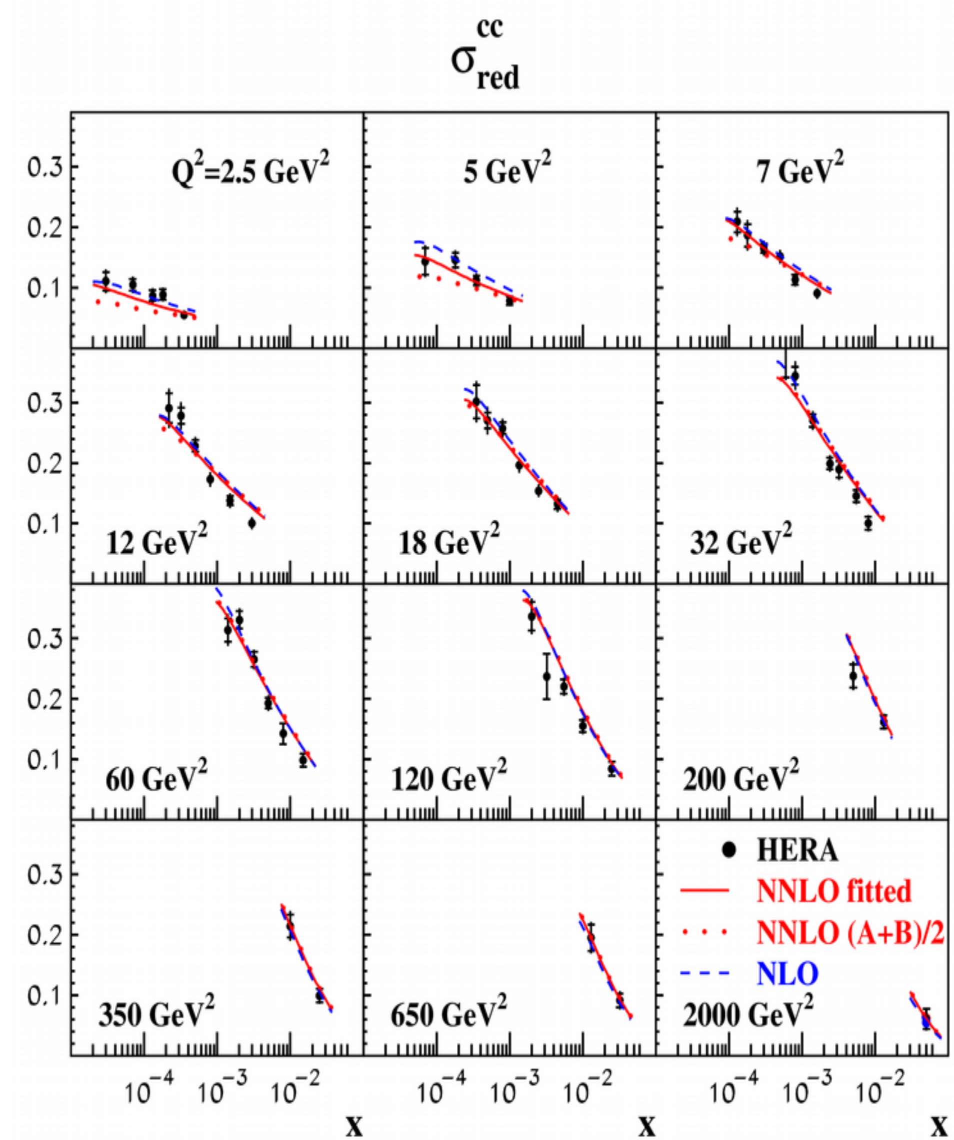


- ATLAS and CMS data on the ratio t/tbar are in a good agreement

- The predictions driven by the forward DY data are in a good agreement with the single-top data

Single-top production discriminate available PDF sets and can serve as a standard candle process

HERA charm data in the ABM fit



sa, Blümlein, Daum, Lipka, Moch PLB 720, 172 (2013)

- Combined H1-ZEUS data on the c-quark DIS

  H1/ZEUS PLB 718, 550 (2012)

- Approximate NNLO massive Wilson coefficients (combination of the threshold corrections, high-energy limit, and the NNLO massive OMEs)

  Kawamura, Lo Presti, Moch, Vogt NPB 864, 399 (2012)

- Running-mass definition of m_c

  χ^2/NDP=61/52

  $m_c(m_c)$=1.15±0.04(exp.) GeV NLO

  $m_c(m_c)$=1.24±0.03(exp.),+0.-0.07(th) GeV NNLO

Good agreement with the e+e- determinations → the FFN scheme nicely works for the existing data

- RT optimal

  χ^2/NDP=82/52 NNLO

  m_c(pole)=1.25 GeV **MMHT14 EPJC 75, 204 (2015)**

- F0NLL

  χ^2/NDP=60/47 NNLO

  m_c(pole)=1.275 GeV **NNPDF3.0 JHEP 1504, 040 (2015)**

- S-ACOT-χ

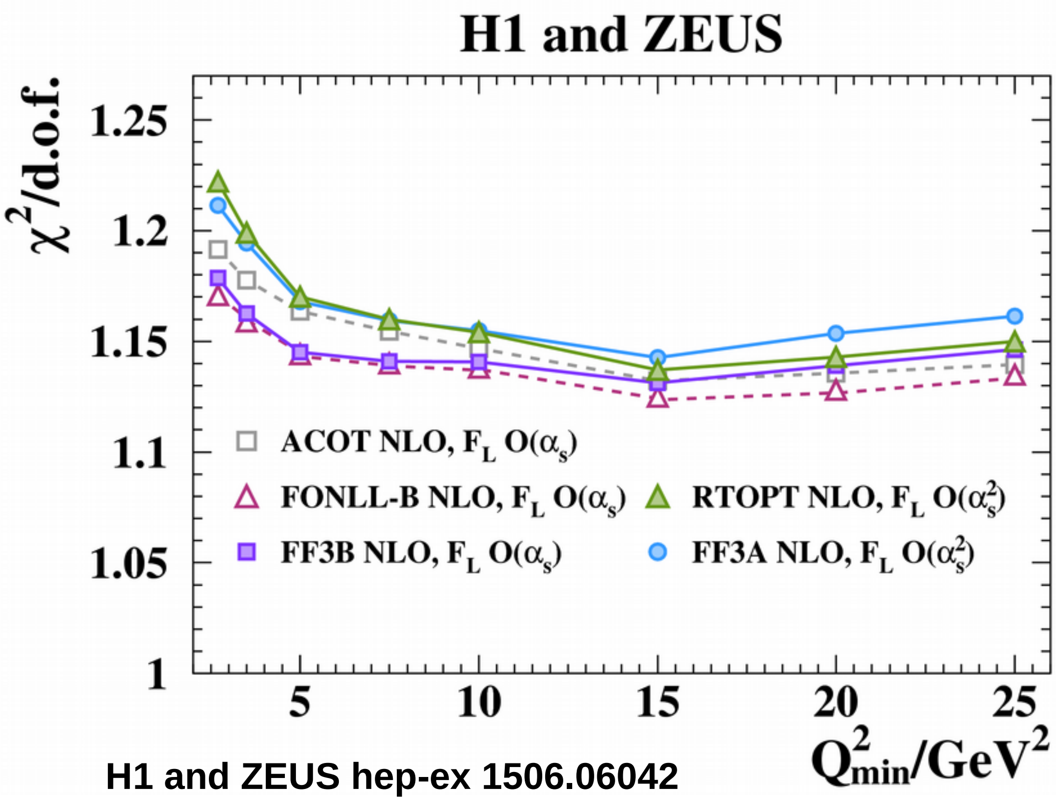
  χ^2/NDP=59/47 NNLO

  m_c(pole)=1.3 GeV **CT14 hep-ph 1506.07443**

$m_c(m_c)$=1.246±0.023 (h.o.) GeV NNLO

Kiyo, Mishima, Sumino hep-ph/1510.07072)

Factorization scheme benchmarking



H1 and ZEUS hep-ex 1506.06042

- Data allow to discriminate factorization schemes
- FFN scheme works very well in case of correct setting (running mass definition and correct value of m_c) → no traces of big logs due to resummation

x_{min}	x_{max}	Q^2_{min} (GeV)	Q^2_{max} (GeV)	$\Delta\chi^2$ (DIS)	N_{dat}^{DIS}	$\Delta\chi^2$ (HERA-I)	N_{dat}^{hera-I}
$4 \cdot 10^{-5}$	1	3	10^6	72.2	2936	77.1	592
$4 \cdot 10^{-5}$	0.1	3	10^6	87.1	1055	67.8	405
$4 \cdot 10^{-5}$	0.01	3	10^6	40.9	422	17.8	202
$4 \cdot 10^{-5}$	1	10	10^6	53.6	2109	76.4	537
$4 \cdot 10^{-5}$	1	100	10^6	91.4	620	97.7	412
$4 \cdot 10^{-5}$	0.1	10	10^6	84.9	583	67.4	350
$4 \cdot 10^{-5}$	0.1	100	10^6	87.7	321	87.1	227

We conclude that the FFN fit is actually based on a less precise theory, in that it does not include full resummation of the contribution of heavy quarks to perturbative PDF evolution, and thus provides a less accurate description of the data

NNPDF PLB 723, 330 (2013)

Strategies employed in the jet data analyzes

CT14

Both Tevatron and LHC data included

Pure NLO, no threshold corrections. Scale is set to individual jet P_T → better perturbative convergence

Carraza, Pires JHEP 1410, 145 (2014)

MMHT14

Tevatron only (exploratory fit to the LHC data)

NLO+threshold corr. (model NNLO for exploratory fit)

NNPDF3.0

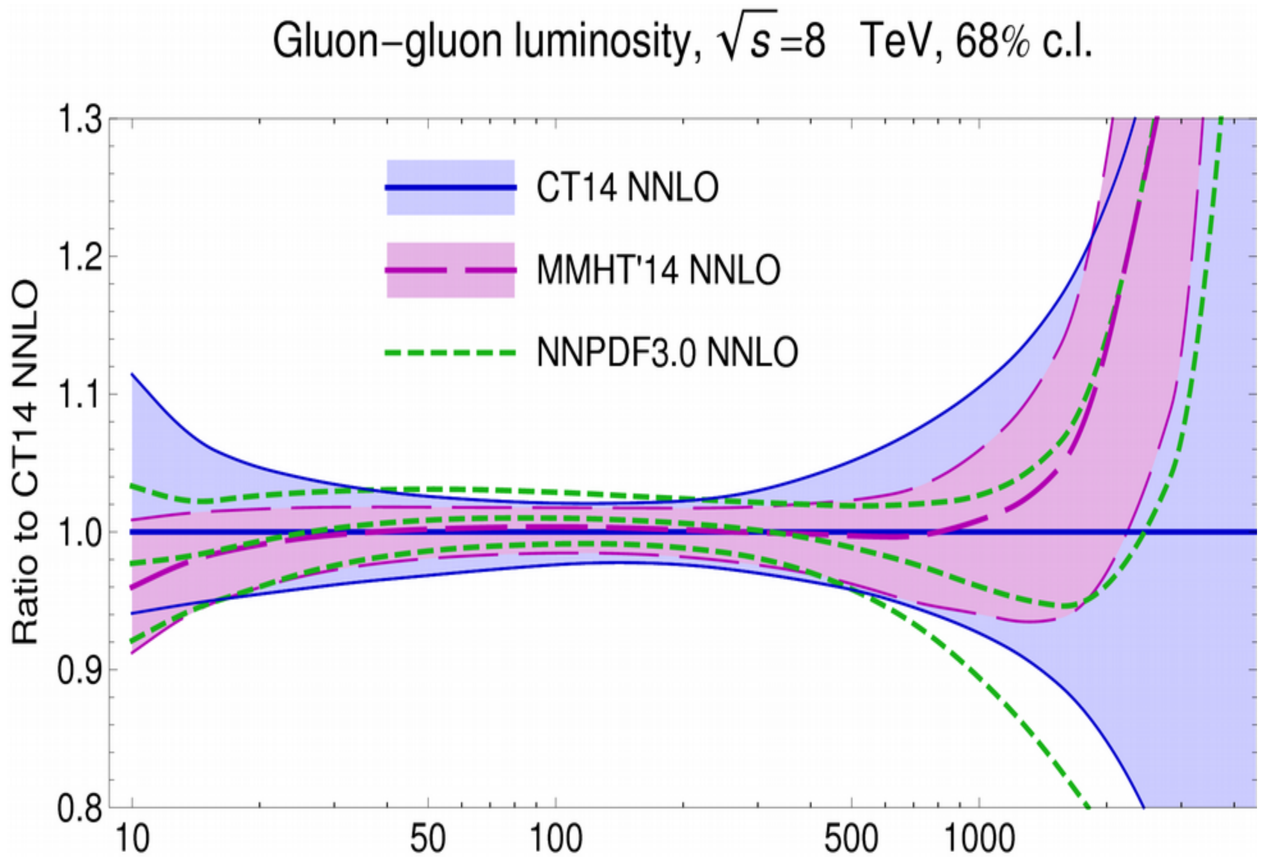
Both Tevatron and LHC (with the "safety" cuts)

NLO+threshold corr.

Good agreement between different approaches →

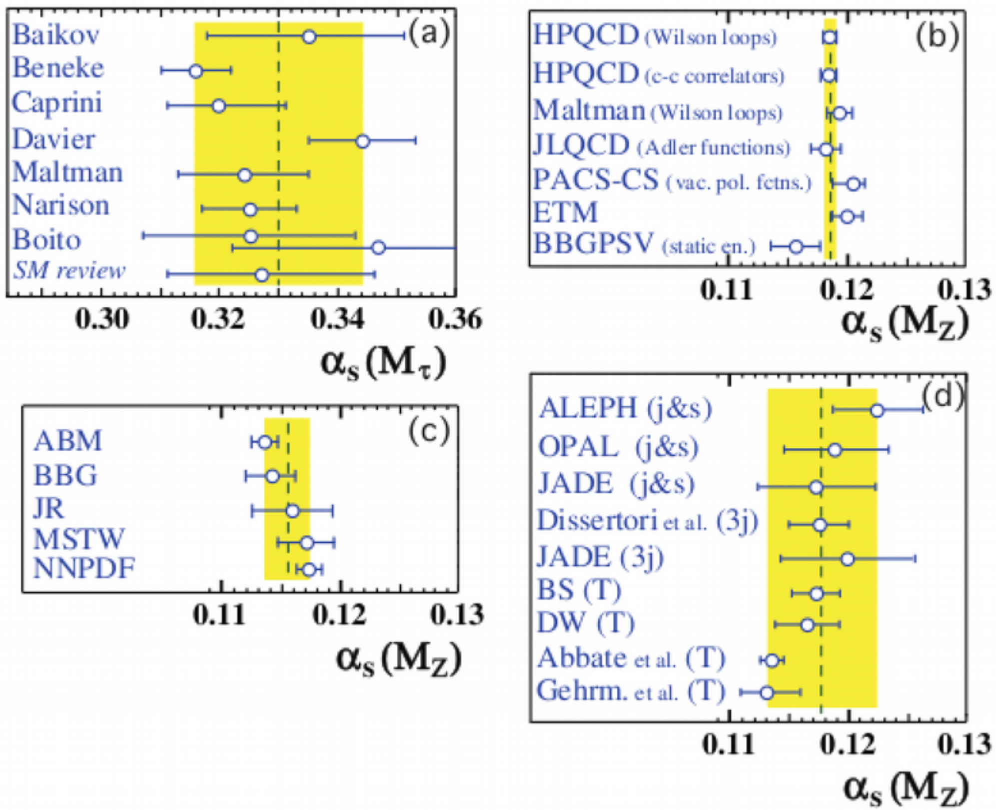
– no impact of the LHC data?

– no impact of the NNLO corrections?



CT14 hep-ph 1506.07443

Value of α_s: perspectives



$\alpha_s(M_Z)=0.1172\pm0.0013$ (NLO, jets)

CMS hep-ex/1412.1633

$\alpha_s(M_Z)=0.1151\pm0.003$ (NLO, t-quark)

CMS hep-ex/1307.1907

$\alpha_s(M_Z)=0.1123\pm0.0015$ (NNLO, e^+e^-, C-parameter)

Hoang, Kolodrubetz, Mateu, Stewart hep-ex/1501.04111

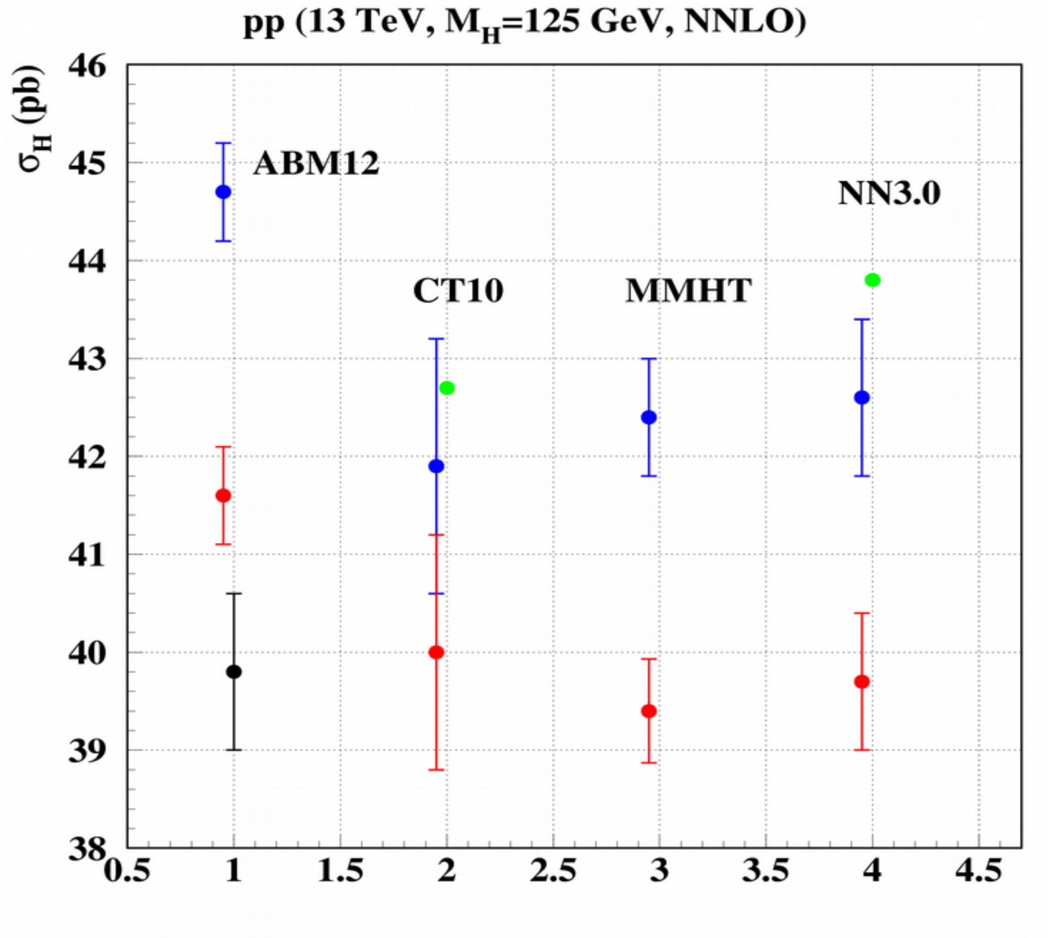
$\alpha_s(M_Z)=0.115,+0.006,-0.004$

CT14 hep-ph 1506.07443

- The uncertainty in world average driven by the lattice determination is 0.0006 (*have been increased by factor of 2 recently, $\alpha_s(M_Z)=0.1170\pm0.0018$ without lattice*)

- Tension between lattice results and other determinations will be probably rising → more conservative estimate of the current uncertainty range is 0.115-0.118

Higgs c.s. in different scenarios



$\alpha_s(M_z)$=0.118, nominal PDFs

$\alpha_s(M_z)$=0.115, nominal PDFs

$\alpha_s(M_z)$=0.118, PDFs with $\alpha_s(M_z)$=0.115

Nominal $\alpha_s(M_z)$ and PDFs

- A spread in c.s. due to straightforward change in α_s
- Change in the gluon distribution due to change in the fit setting, which can lead both to the change in α_s and gluons → difficult to estimate in advance, roughly gives smaller effect
- Crude combination of these two gives an uncertainty of ~4 pb (10 %).

Summary

- Recent TEVATRON and LHC data provide valuable constraint on the small- and large x quark iso-spin asymmetry
  - the sea asymmetry is negative at $x \sim 10^{-3}$; an onset of the Regge asymptotics still may occur at $x < 10^{-5}$
  - large-x asymmetry can be determined with a good accuracy w/o using the DIS data on deuterium target → reduced theoretical uncertainties in PDFs
  - nice agreement with the LHC single-top production data; standard candle for the d/u ratio

- Comparing to the “truly global” PDF sets (CT14, MMHT14, NNPDF3.0)
  - better coverage of the forward DY data → improved quark distributions
  - solid theoretical treatment and better description of the heavy-quark in DIS → reliable small-x gluon determination
  - overall NNLO accuracy of the fit → no impact of the missing NNLO corrections on the value of α_s and various predictions (Higgs, t-quark, etc.)

EXTRAS

The fit ingredients

DATA:

- DIS NC inclusive (no deuteron data included)
- DIS CC inclusive
- DIS charm production
- DIS μμ CC production (NOMAD)
- DIS charmed-hadron CC production (CHORUS)
- fixed-target DY
- LHC DY distributions (ATLAS, CMS, LHCb)

QCD:

- NNLO evolution
- NNLO massless DIS and DY coefficient functions
- NLO+ massive DIS coefficient functions (**FFN scheme**)
  - – NLO + NNLO threshold corrections for NC
  - – NNLO CC at Q>> m_c
  - – running mass
- NNLO exclusive DY (FEWZ 3.1)
- NNLO inclusive ttbar production (pole / running mass)
- Relaxed form of (dbar-ubar) at small x

Power corrections in DIS:

- target mass effects
- dynamical twist-4 terms

NNLO DY corrections in the fit

The existing NNLO codes (DYNNLO, FEWZ) are quite time-consuming → fast tools are employed (FASTNLO, Applgrid,.....)

- the corrections for certain basis of PDFs are stored in the grid
- the fitted PDFs are expanded over the basis
- the NNLO c.s. in the PDF fit is calculated as a combination of expansion coefficients with the pre-prepared grids

The general PDF basis is not necessary since the PDFs are already constrained by the data, which do not require involved computations → *use as a PDF basis the eigenvalue PDF sets obtained in the earlier version of the fit*

$\mathbf{P_0} \pm \Delta\mathbf{P}_0$ – vector of PDF parameters with errors obtained in the earlier fit
E – error matrix
P – current value of the PDF parameters in the fit

- store the DY NNLO c.s. for all PDF sets defined by the eigenvectors of **E**
- the variation of the fitted PDF parameters ($\mathbf{P} - \mathbf{P}_0$) is transformed into this eigenvector basis
- the NNLO c.s. in the PDF fit is calculated as a combination of transformed ($\mathbf{P} - \mathbf{P}_0$) with the stored eigenvector values