PDF WG summary (cont'd)

Conventional PDF shapes

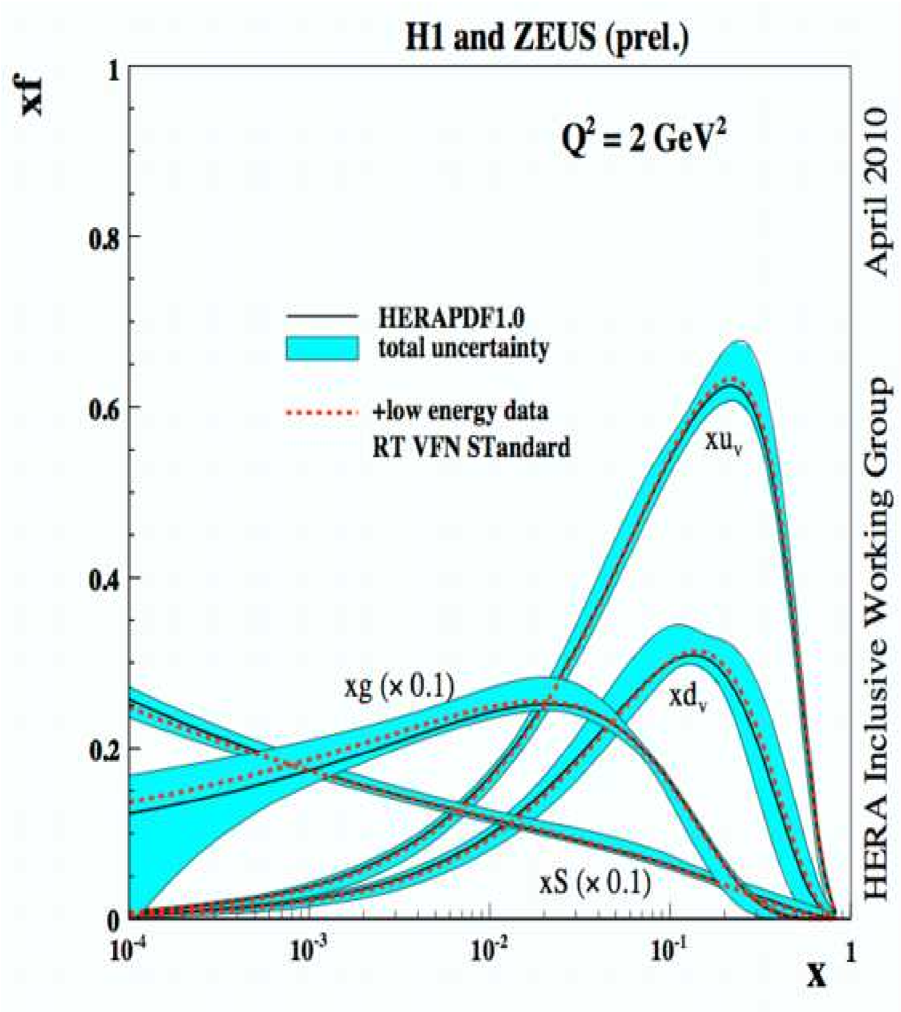
- impact of the new data (inclusive F_2 and F_L, $W^{\pm}$ and charged lepton asymmetry, inclusive jet production)
- The heavy-quark electroproduction (semi-inclusive F_2^{cc} and F_2^{bb})
- improved techniques (improved statistical techniques, study of PDF flexibility and uncertainties)

Theoretical constraints on PDFs

The nuclear corrections

Non-conventional PDFs

Radescu/HERAPDF

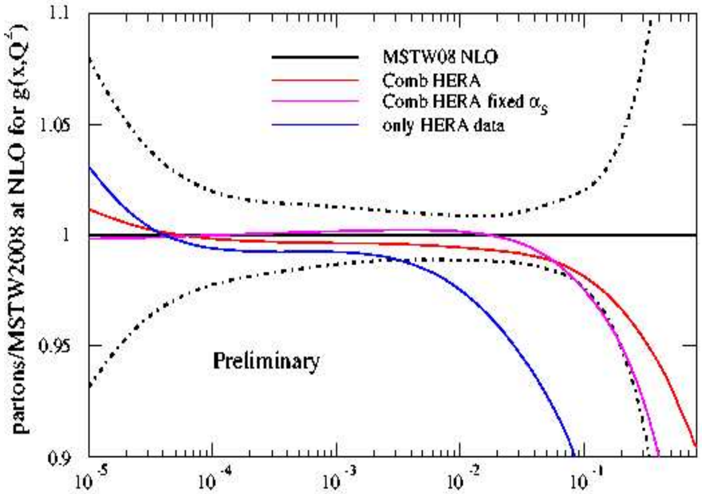


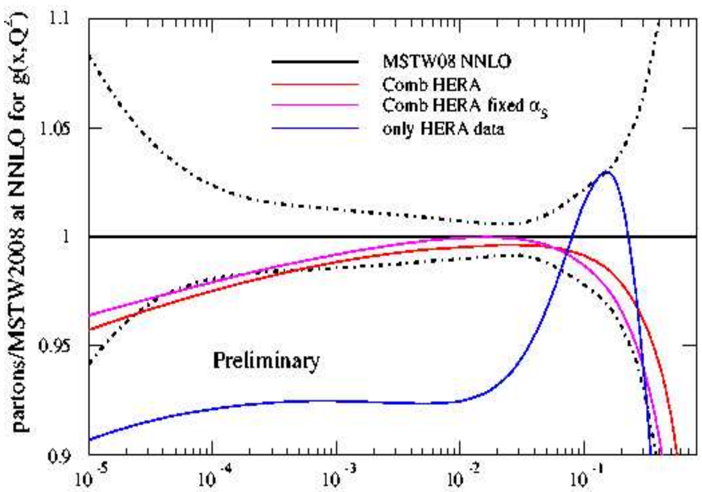
- Study impact of the inclusive data on PDFs
- Test sensitivity to different heavy flavour treatments
- NNLO corrections are implemented

$$\alpha_s(M_Z) = 0.1166 \pm 0.0044\,(NLO)$$

$$\alpha_s(M_Z) = 0.1145 \pm 0.0042\,(NNLO)$$

Thorne/MSTW



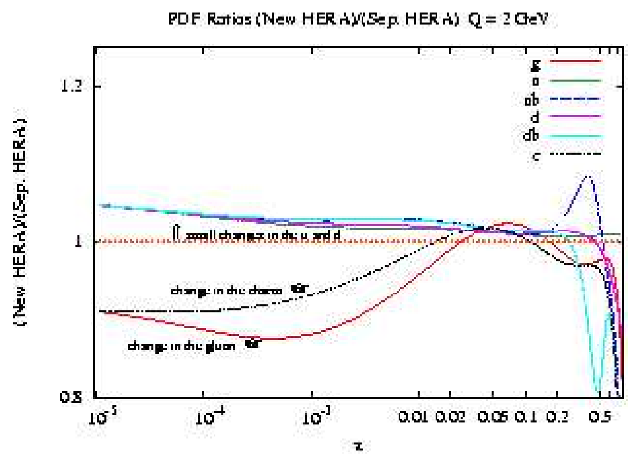


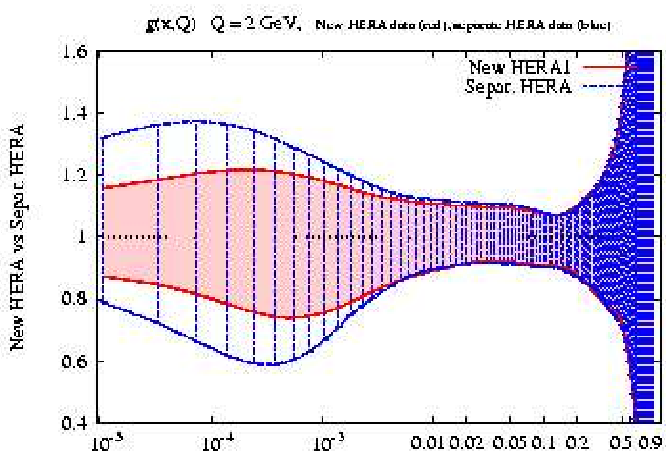
- NLO: Global fit quality: 2610/2471. Significant effect in places, but generally not actually bigger than potential effects from variation of GMVFNS.
- NNLO: Global fit quality 2505/2387. Significant effect in places. Very little dependence on whether α_s left free.

$$\alpha_s(M_Z) = 0.1215(NLO)$$

$$\alpha_s(M_Z) = 0.1178(NNLO)$$

Guzzi/CTEQ





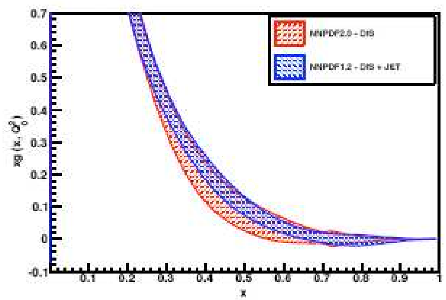
- For the NLO CTEQ fit the combined HERA data prefer the lower gluon distribution at small x.
- The uncertainty in the gluons at small x is essentially reduced due to inclusion of new data.
- Normalizations are treated as the same footing as the other correlated uncertainties

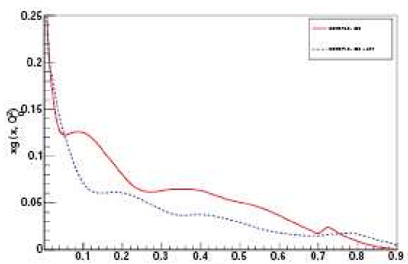
Impact of modifications

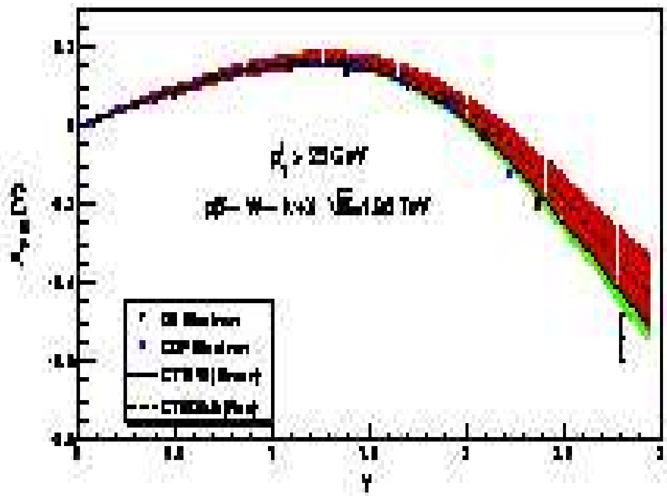
Tevatron inclusive Jet data

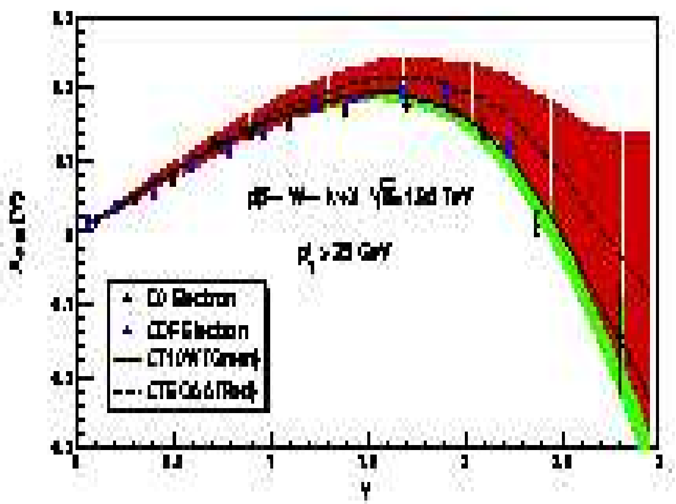
Fit	NNPDF1.2	NNPDF1.2+IGA	NNPDF1.2+IGA+t_0	2.0 DIS	2.0 DIS+JET
χ^2_{tot} $\langle E \rangle$	1.32 2.79	1.16 2.41	1.12 2.24	1.20 2.31	1.18 2.28
$\langle \chi^{2(k)} \rangle$	1.60	1.28	1.21	1.29	1.27
CDFR2KT	*1.10*	*0.95*	*0.78*	*0.91*	0.79
D0R2CON	*1.18*	*1.07*	*0.94*	*1.00*	0.93

- Tevatron Run-II inclusive jet data provide a valuable constrain on large-x gluon.
- No incompatibility.
- Run-I data not included but compatibility with the outcome of the fit has been checked.

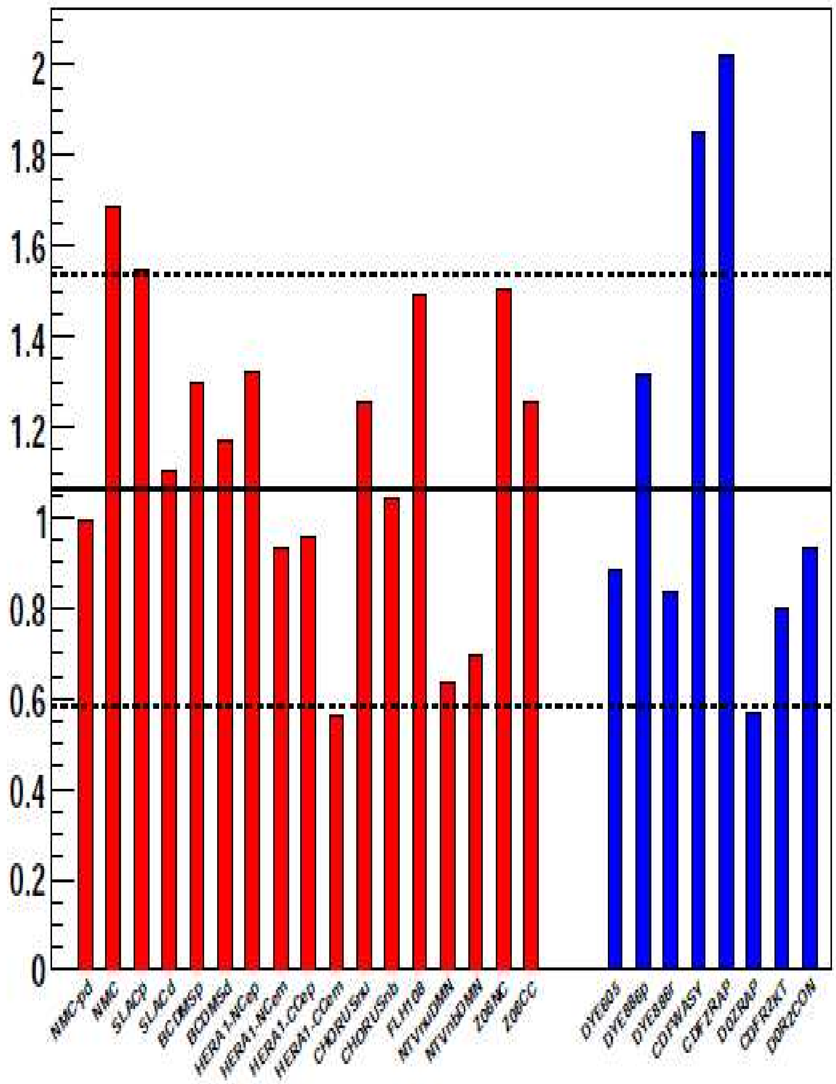






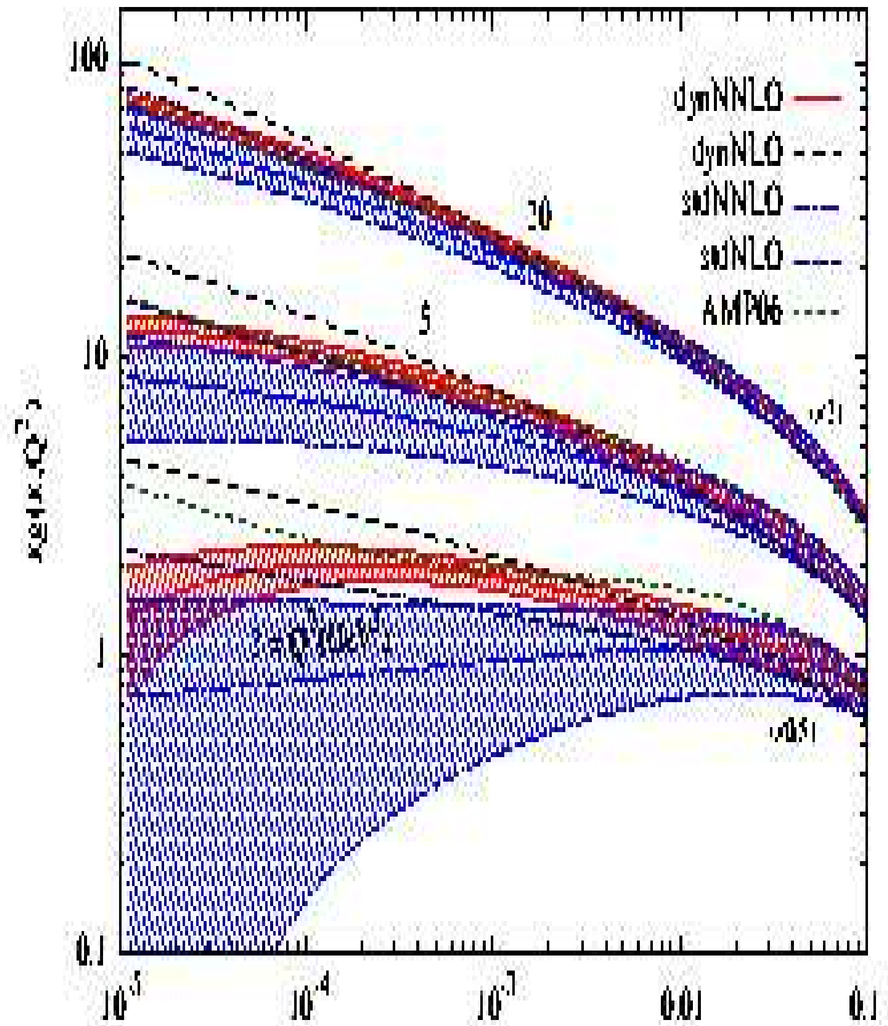


- Good fits to electron (e) asymmetry data are possible without NMC and BCDMS; and vice versa. No acceptable fit to D0 II electron asymmetry and NMC/BCDMS data can be achieved. Tension between Run-2 electron asymmetry and D0 Run-2 muon asymmetry.
- Two variants of the fit, CT10 and CT10W, with(out) Tevatron Run-2 data. CT10W agrees better with the W asymmetry data; has smaller uncertainty than CT10.



Ubiali/NNPDF

- NNPDF2.0: very flexible shape of the PDFs (cf. Chebyshev polynomials Radescu,Nadolsky)
- DIS data combined with the hadronic data (Drell-Yan and inclusive jet production).
- NLO computation of hadronic observables too slow for parton global fits. K-factor depends on PDFs and it is not always a good approximation. Built up FastKernel code for computation of DY observables.
- No obvious tension between hadronic and DIS data



Jimenez-Delgado

- At low-enough Q^2 only "valence" partons would be "resolved" structure at higher Q^2 appears radiatively (i.e. due to QCD dynamics)
- Positive definite input distributions defined at $Q_0^2 < 1\ \mathrm{GeV}^2$ (optimally determined).
- QCD predictions for $x \lesssim 0.01$ more restrictive.
- Standard gluons fall below dynamical

Theoretical hints

- Restrictions on the initial parton densities: non-singular input for the PDFs evolution Ermolaev
- Evidence for deviations from NLO DGLAP, compatible with resummation / saturation, but not with NNLO Caola
- Effect of the gluino contribution to the QCD evolution revisited Guzzi
- Quantitative comparison of the proton, photon, and diffractive structure function at $Q_2 = 0.3$ GeV^2 Klimkovich
- Unitarity model for the DIS and predictions for EIC Tywonyuk

Jimenes-Delgado

Effective heavy-quark PDFs: VFNS

Idea: Resum (RGE) the $\ln \frac{\mu^2}{m^2}$ *to gain calculational power*

Asymptotically ($Q^2 \gg m^2$):

$$H(\tfrac{Q^2}{\mu^2}, \tfrac{\mu^2}{m^2}) \longrightarrow A(\tfrac{\mu^2}{m^2}) \otimes C(\tfrac{Q^2}{\mu^2})$$

A's=massive OME's, **process independent!!**

C's=light-parton coefficient functions

Light-parton PDFs $\xrightarrow{A\text{'s}}$ effective **HQ**-PDFs

assumed to be correct **asymptotically**

Ressumation of **final-state** contributions

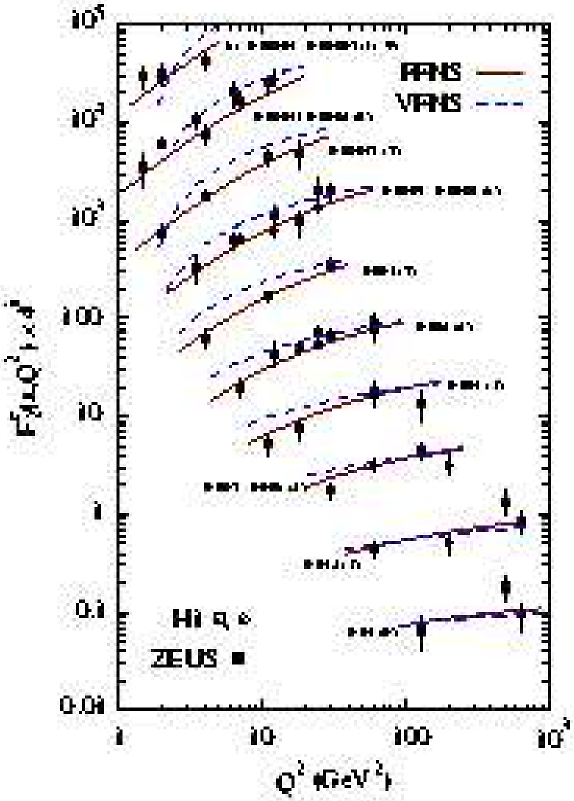
($\neq$ intrinsic heavy-quark content)

In practice: massless evolution increasing n_f

at unphysical "thresholds" $\mu^2 \simeq m^2$ (not $\hat{s} \gtrsim 4m^2$)

Input determined always in the FFNS!!

(most data in threshold region)



VFNS HQ-PDFs generated **from FFNS preserving universality**

6 extreme variations tried, along with ZM-VFNS

GMVFNS1 – $b = -1, c = 1$.

GMVFNS2 – $b = -1, c = 0.5$.

GMVFNS3 – $a = 1$.

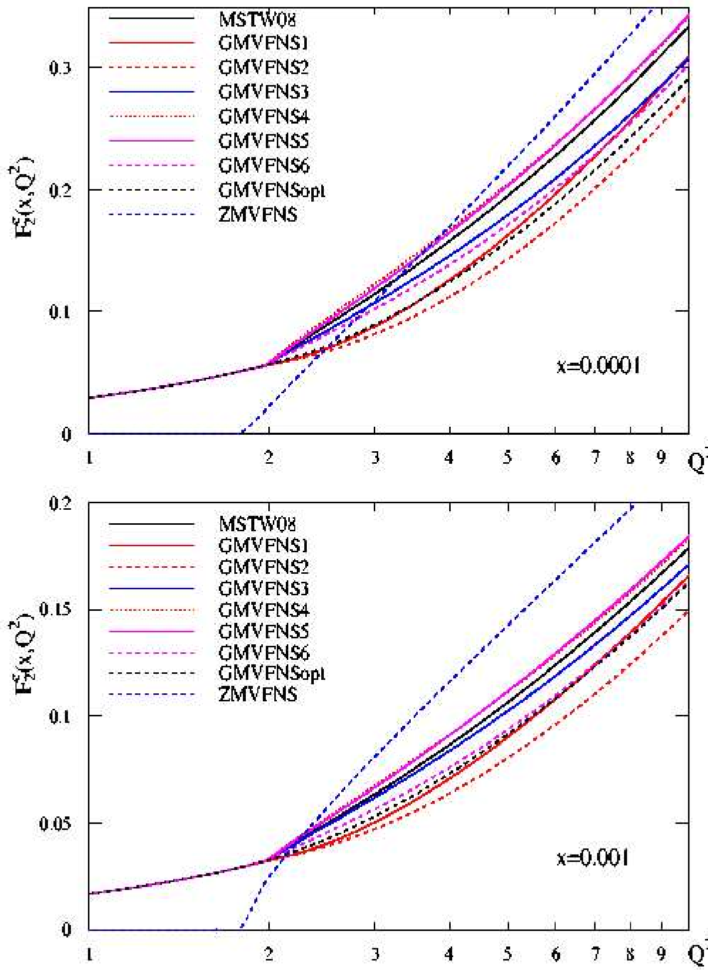
GMVFNS4 – $b = +0.3, c = 1$ – fit.

GMVFNS5 – $d = 0.1$ – fit.

GMVFNS6 – $d = -0.2$ – fit.

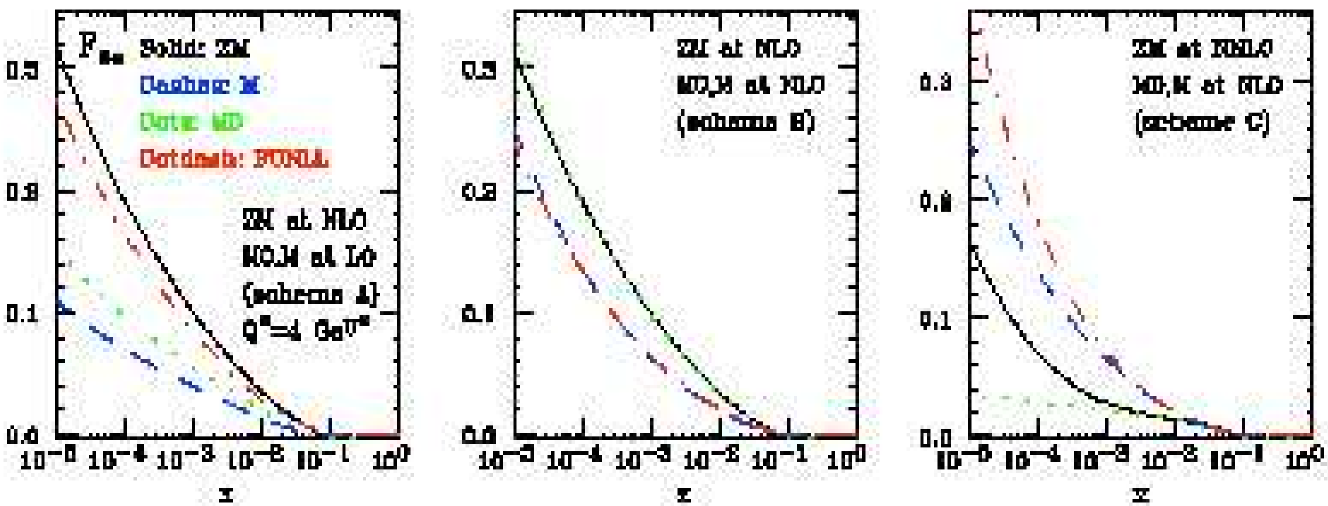
Variations in $F_2^c(x, Q^2)$ near the transition point at NLO due to different choices of GM-VFNS.

Optimal, $a = 1, b = -2/3, c = 1$, smooth behaviour.



$F_{2c}(x, Q^2)$ in FONLL

The different contributions to FONLL for $F_{2c}(x, Q^2)$:



In FONLL scheme B ZM$\sim$MD even at $Q^2 \sim 20$ GeV^2 , so FONLL$\sim$Massive

Greatly reduced sensitivity to choice of (arbitrary) threshold prescription present in scheme A

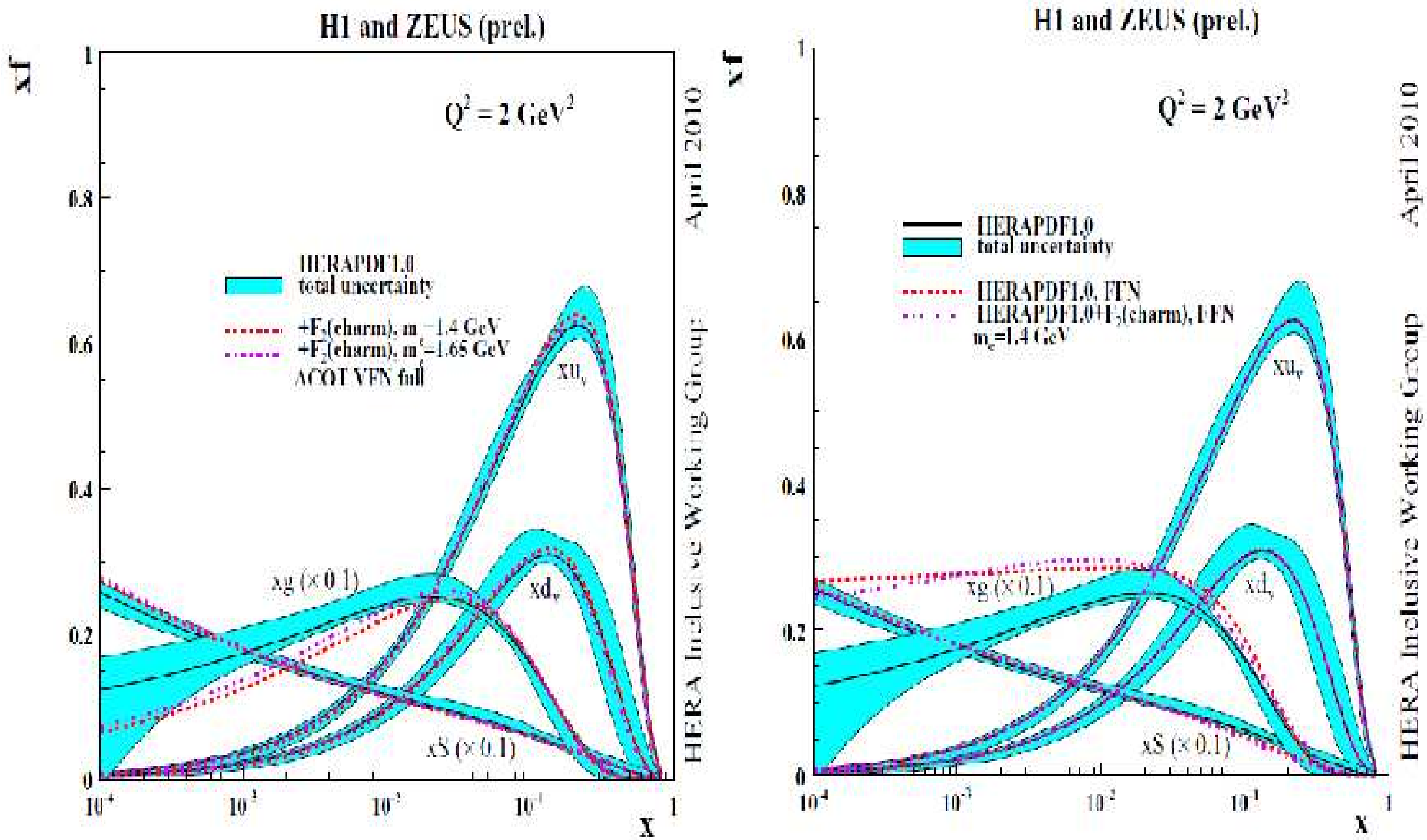
In all schemes mass-suppressed corrections are important even at moderate Q^2

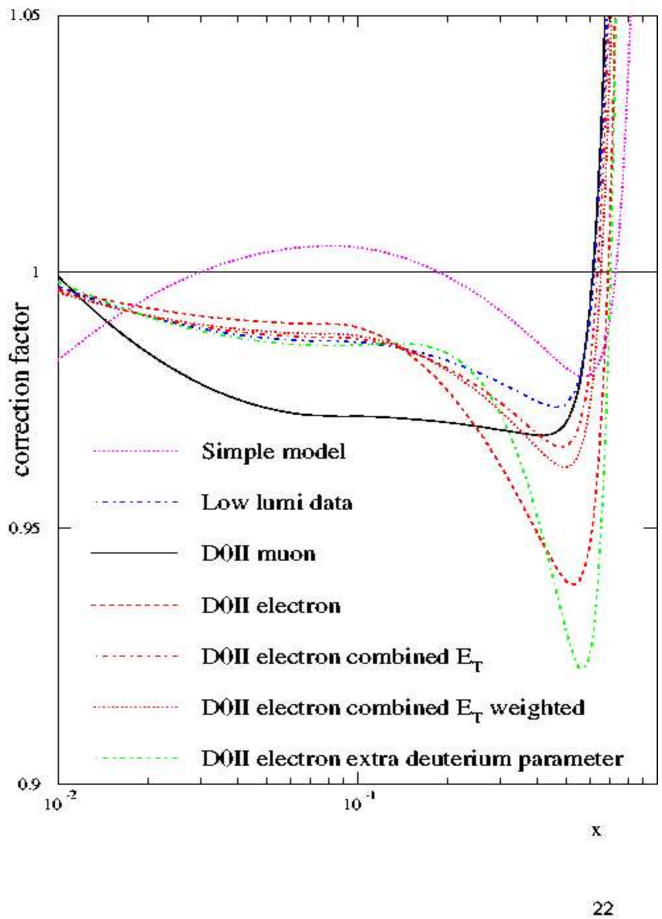
scheme	RT Std m_c=1.4	RT Std m_c=1.65	RT Opt m_c=1.4	RT Opt m_c=1.65	ACOT m_c=1.4	ACOT m_c=1.65	#points
χ^2	730.7	627.5	644.6	695.4	653.9	605.7	633
$F_2^{(charm)}$ Sub χ^2	134.5	43.5	64.8	100.1	89.5	41.4	41

scheme	FFN m_c=1.4	FFN m_c=1.65	#points	FFN m_c=1.4 no F_2^c	#points
χ^2	567.0	852.0	565	512.9	524
$F_2^{(charm)}$	51.7	248.9	41		0

- The best values of χ^2 are comparable for the ACOT, RT(Standard), RT(Optimized), and FFN schemes, provided the value of m_c is adjusted too.
- ACOT gluon shape is suppressed compared to the Standard RT VFN scheme used for HERAPDF1.0
- The FFN gluon shape is VERY different from that of the Standard RT VFN scheme used for HERAPDF1.0.

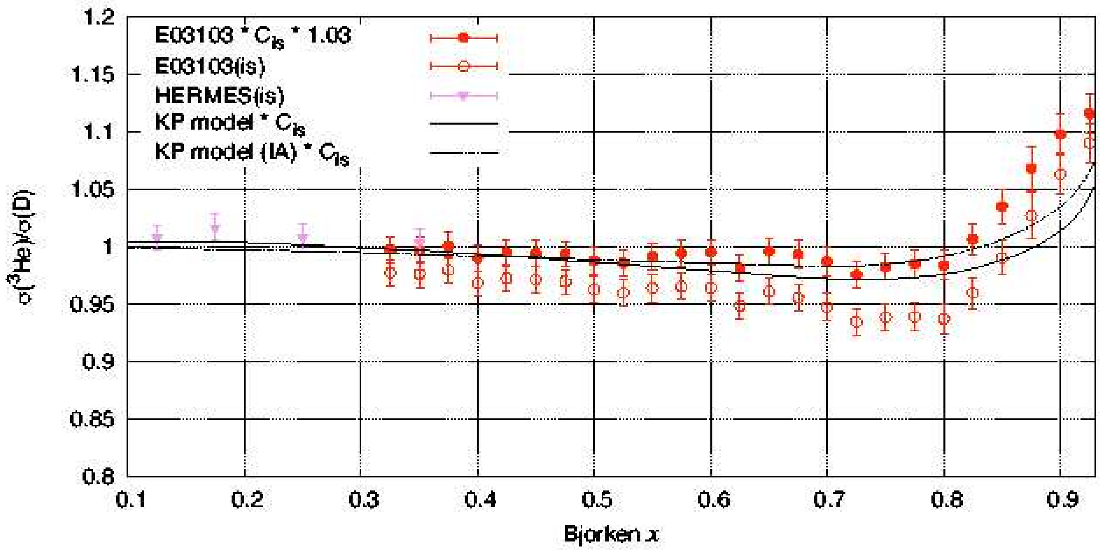
Plačakytė&Cooper-Sarkar/HERAPDF





- Standard ts give very poor comparison to both D0 electron and muon data and modification of the valence distribution x-shape improves the fit quality only by 2 units.
- Also try more sophisticated approach to corrections for deuterium data (cf. fit of the nuclear corrections Kovarik).
- Deuterium corrections help significantly but are very large/unusual for best ts to muon or electron asymmetry in both p_T bins.

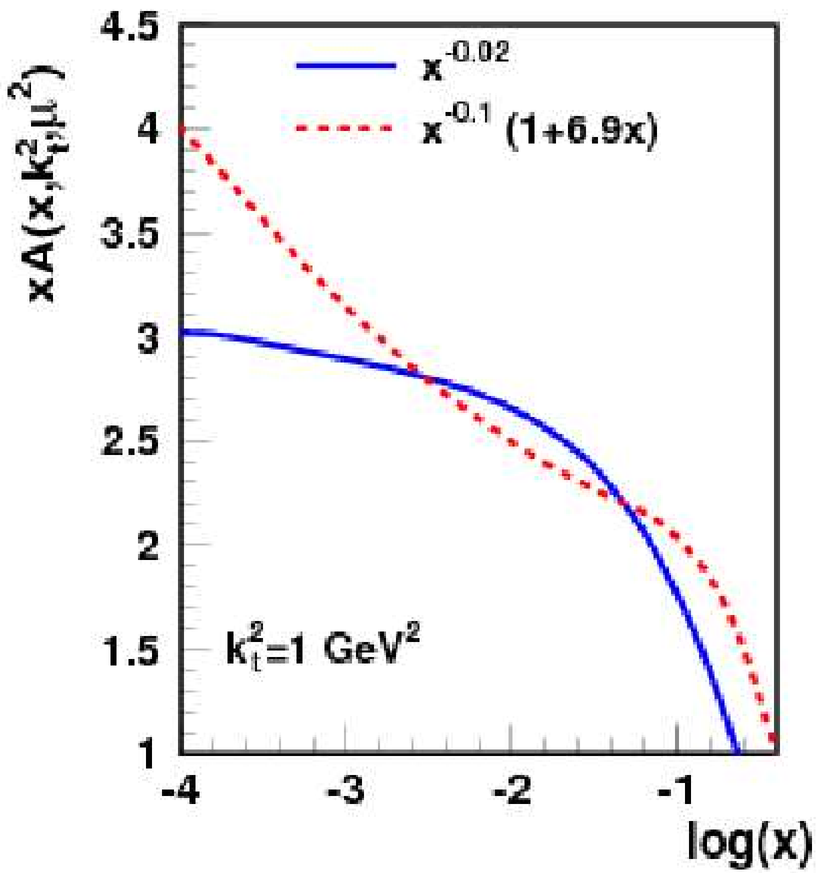
PREDICTIONS FOR ^{3}He/D



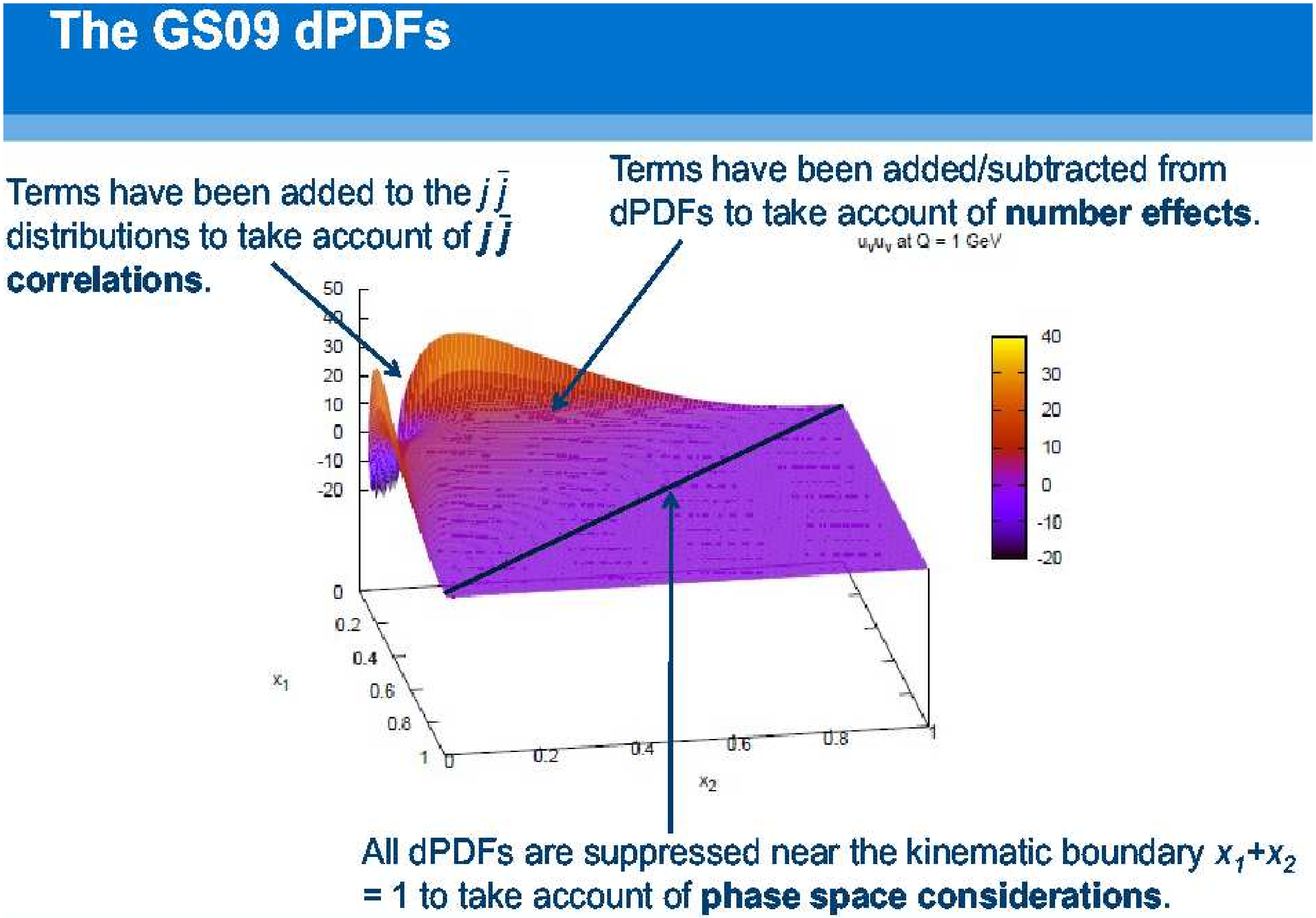
- Apply normalization factor from F_2^n/F_2^p and our $C_{\rm is}$ correction to JLab raw data
  $\Longrightarrow$ Consistent normalization with HERMES measurement of (isoscalar) ^{3}He/D

- Use ^{3}He spectral function with terms for bound pn deuteron intermediate state, pn continuum scattering states ($\mathcal{P}^p$) and pp continuum scattering states ($\mathcal{P}^n$)
  R. Schulze and P. Sauer, Phys. Rev. C 48 (1993) 38

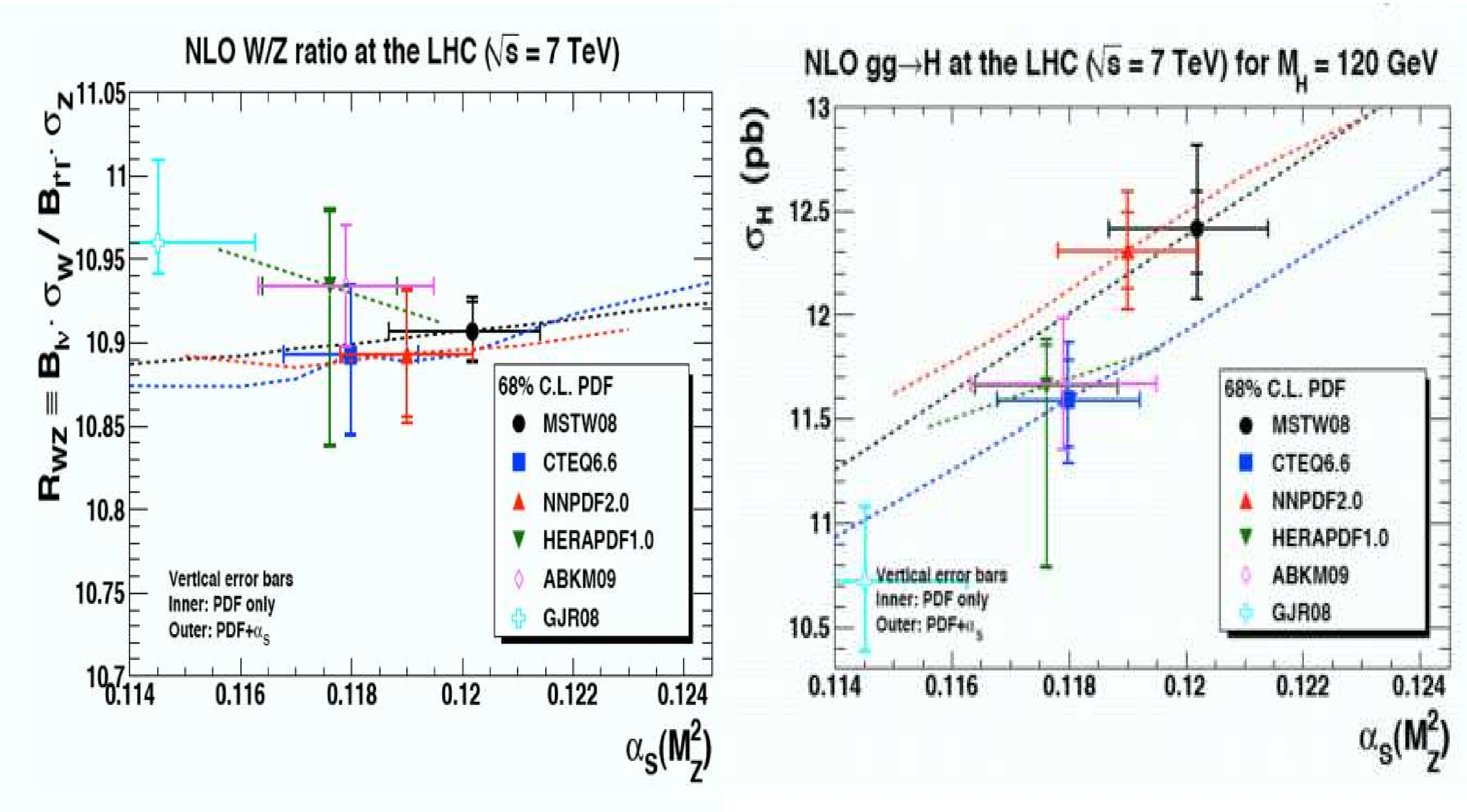
- Good agreement of our predictions with both JLab and HERMES ^{3}He/D data



- New fits of the unintegrated gluon densities the combined HERA inclusive data have been performed.
- The new gluon is more pronounced at low and high x (cf. high-energy resummation in the prompt photon production Diana)
- The value of χ^2/NDP is significantly higher than in the fit to earlier HERA data – 2.2 versus 1.2.


The GS09 dPDFs
Terms have been added to the $j\bar{j}$ distributions to take account of $j\bar{j}$ correlations.
Terms have been added/subtracted from dPDFs to take account of number effects.
$u_v u_v$ at Q = 1 GeV
x_1
x_2
All dPDFs are suppressed near the kinematic boundary x_1+x_2 = 1 to take account of phase space considerations.

Huston


NLO W/Z ratio at the LHC (√s = 7 TeV)
$R_{WZ} \equiv B_{l\nu} \cdot \sigma_W / B_{l^+l^-} \cdot \sigma_Z$
$\alpha_S(M_Z^2)$
68% C.L. PDF
MSTW08
CTEQ6.6
NNPDF2.0
HERAPDF1.0
ABKM09
GJR08
Vertical error bars
Inner: PDF only
Outer: PDF+α_S
NLO gg→H at the LHC (√s = 7 TeV) for M_H = 120 GeV
σ_H (pb)
$\alpha_S(M_Z^2)$
68% C.L. PDF
MSTW08
CTEQ6.6
NNPDF2.0
HERAPDF1.0
ABKM09
GJR08
Vertical error bars
Inner: PDF only
Outer: PDF+α_S

Thanks to all speakers