HERAPDF status

Data and PDFs

PDF4LHC Nov 28th 2011

A M Cooper-Sarkar

What data:

HERA-II inclusive NC/CC e+ and e- at Ep=920 GeV plus high-x extension

HERA-II inclusive NCe+ at Ep=460 and 575 GeV- low Q2 extension

HERA F2c combination

HERA inclusive +jets

What PDFs:

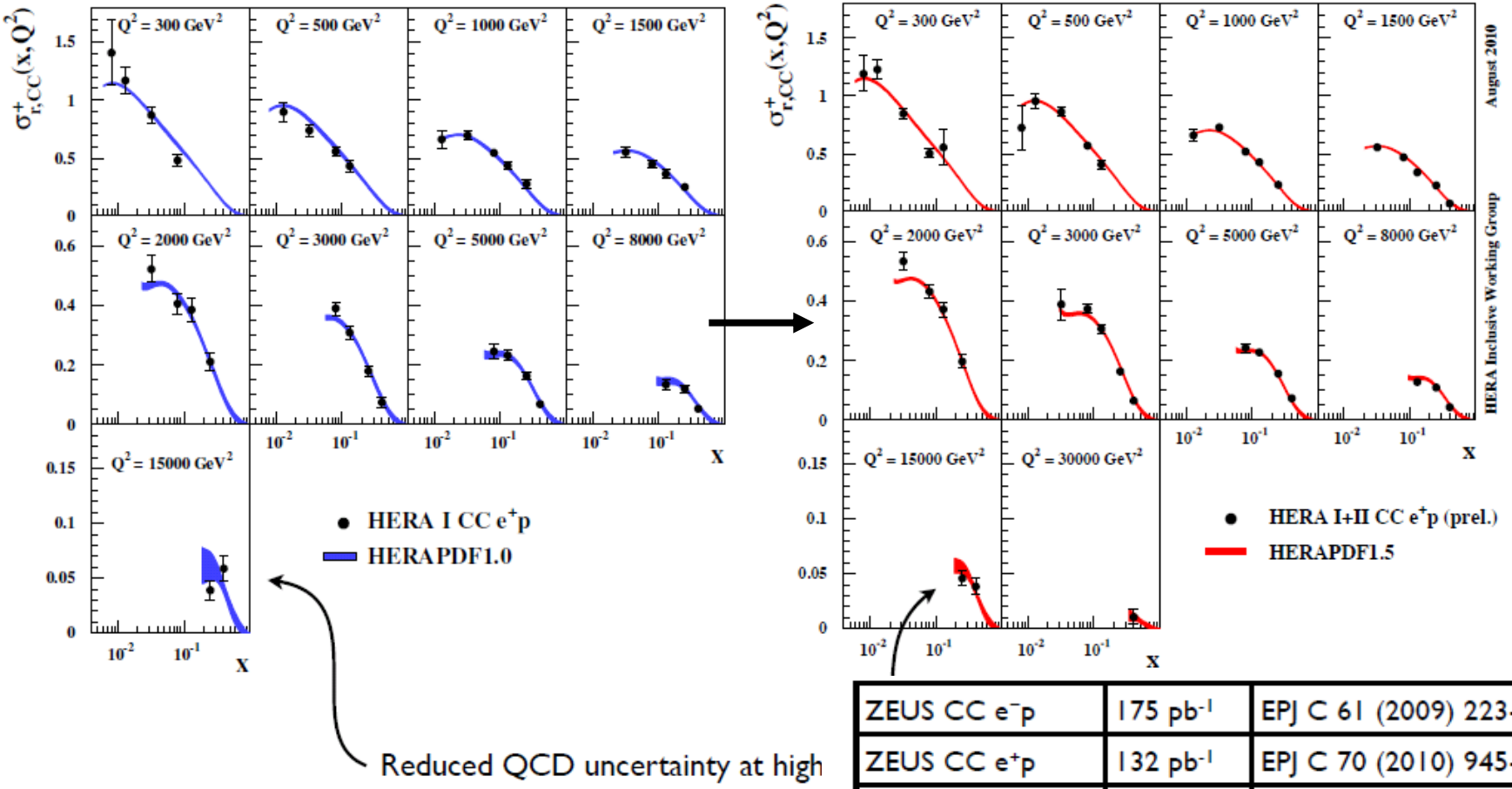
HERAPDF1.5NLO and NNLO on LHAPDF5.8.6

HERAPDF1.6 with jets and determination of $\alpha_S(M_Z)$

HERAPDF1.7 combining all data

Update HERAPDF1.0 to HERAPDF1.5 NLO: update of data AND fit

JHEP1001:109 (2010): 100pb^{-1} e^{+} , 15pb^{-1} e^{-} , per experiment

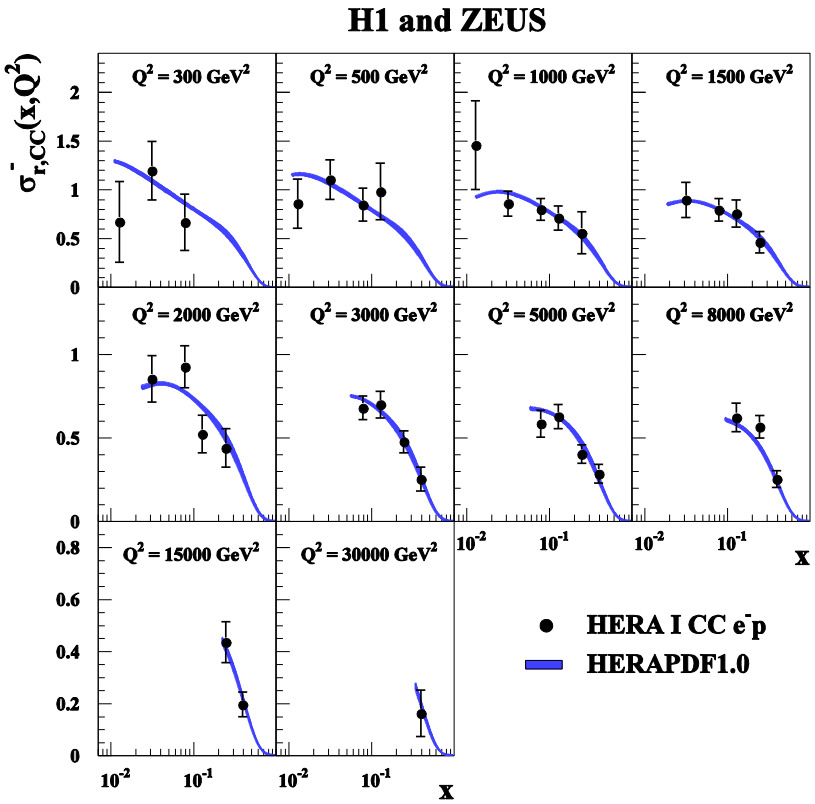


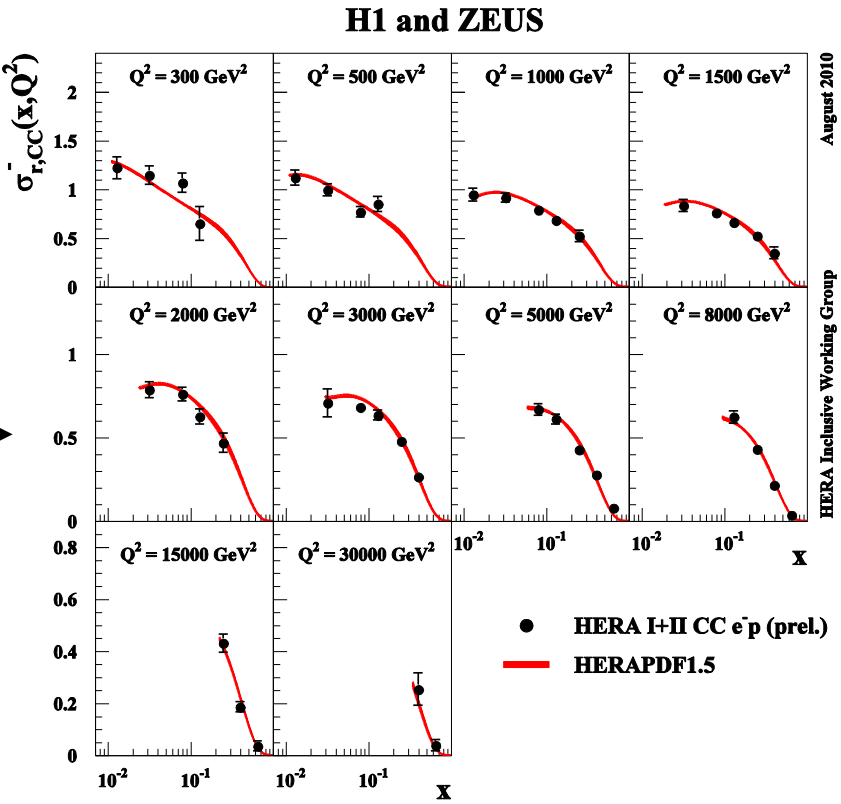
Reduced QCD uncertainty at high

ZEUS CC e$^-$p	175 pb^{-1}	EPJ C 61 (2009) 223-235
ZEUS CC e$^+$p	132 pb^{-1}	EPJ C 70 (2010) 945-963
ZEUS NC e$^-$p	170 pb^{-1}	EPJ C 62 (2009) 625-658
ZEUS NC e$^+$p	135 pb^{-1}	ZEUS-prel-11-003
H1 CC e$^-$p	149 pb^{-1}	H1prelim-09-043
H1 CC e$^+$p	180 pb^{-1}	H1prelim-09-043
H1 NC e$^-$p	149 pb^{-1}	H1prelim-09-042
H1 NC e$^+$p	180 pb^{-1}	H1prelim-09-042

Preliminary HERA I+II data combination
ZEUS-prel 10-017
H1prelim-10-141
Does not have the ZEUS-prel-11 result
Still waiting for FINAL data

Update HERAPDF1.0 to HERAPDF1.5 NLO: update of data AND fit





Much more e- data

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ZEUS NC e^-p	170 pb^{-1}	EPJ C 62 (2009) 625-658
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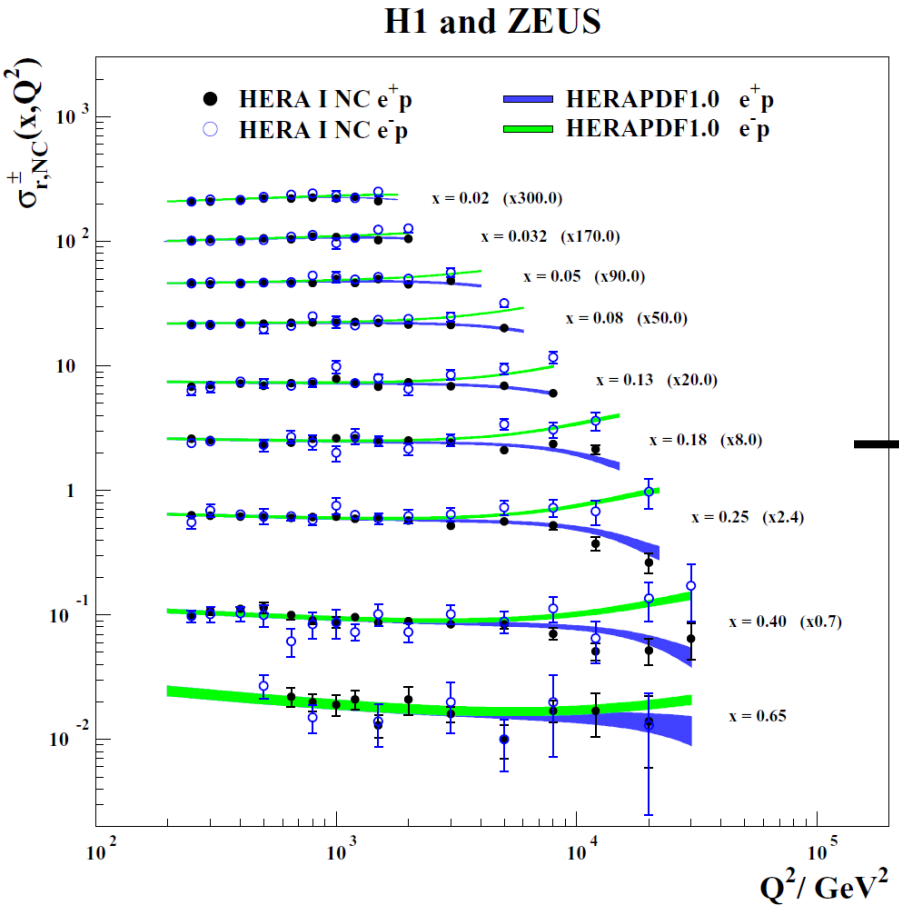
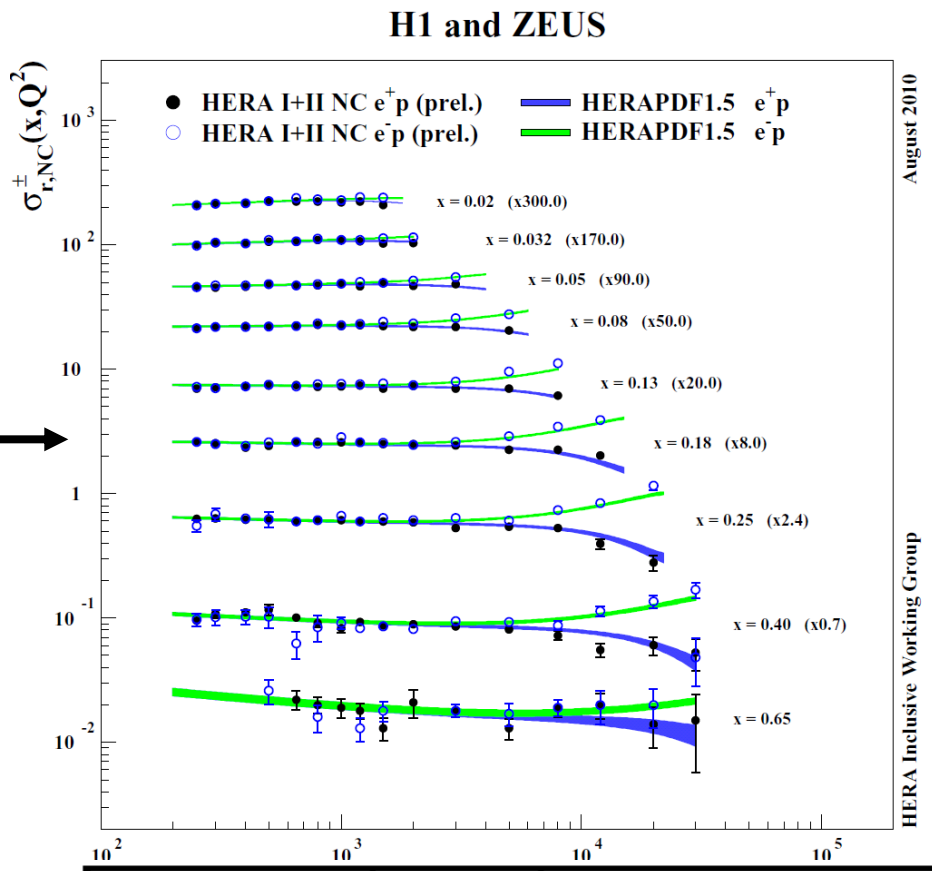
Update HERAPDF1.0 to HERAPDF1.5 NLO: update of data AND fit





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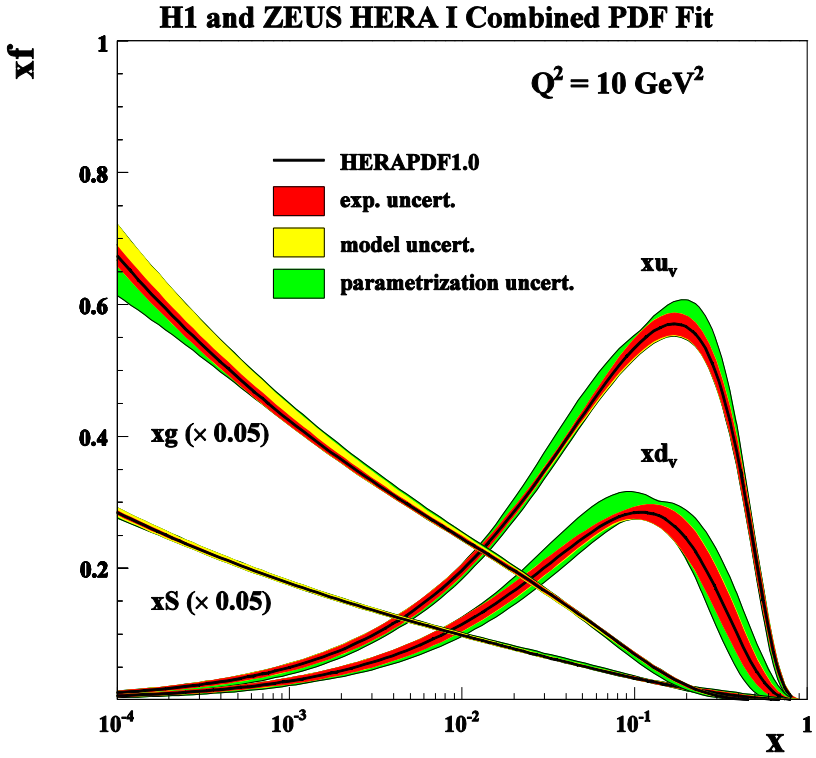
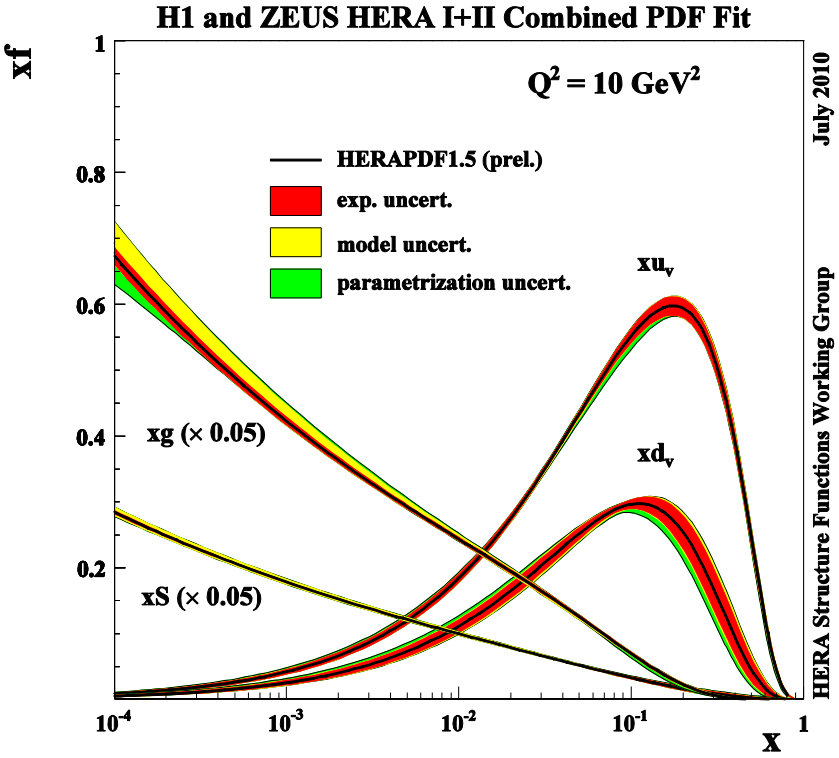
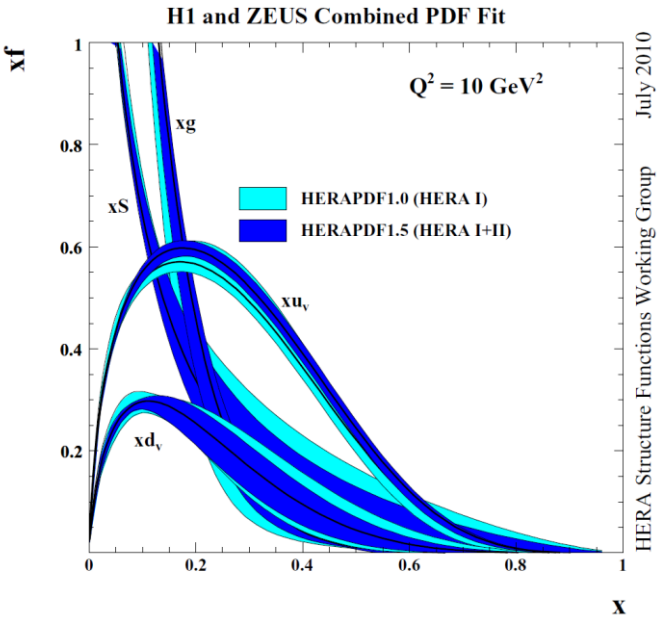




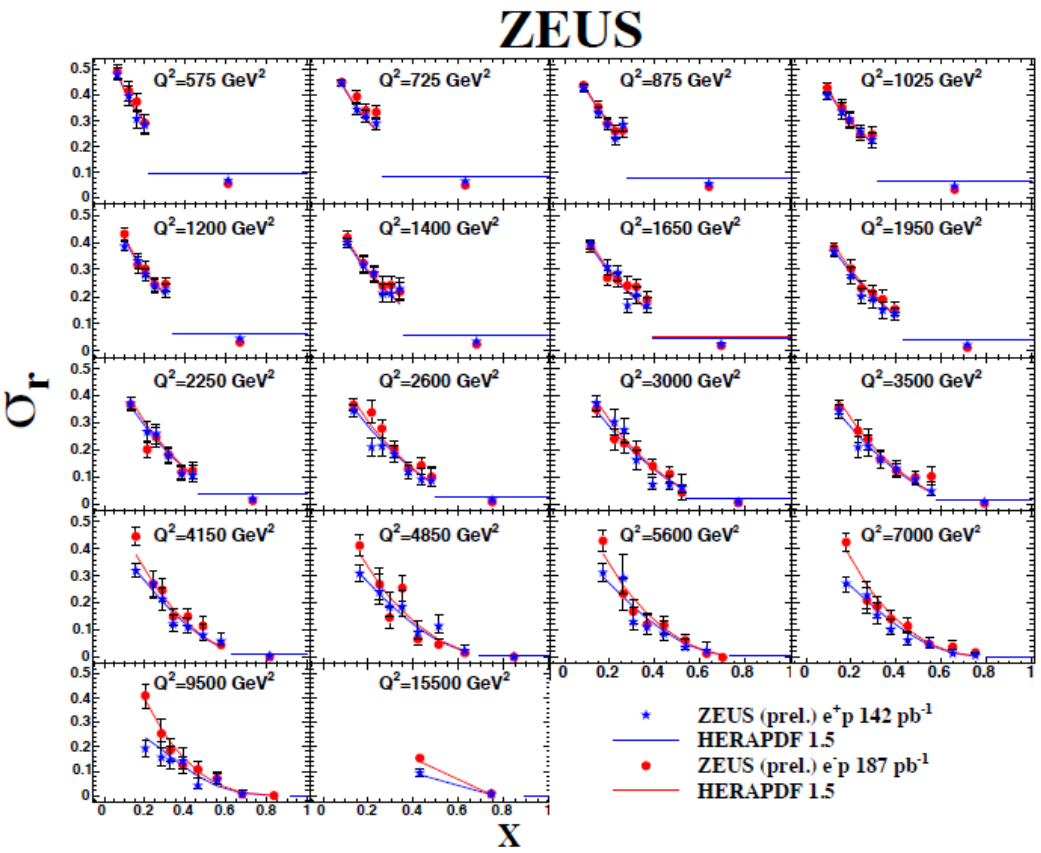


HERAPDF1.5 PDF analysis of these HERA I+II data
ZEUS-prel 10-018
H1prelim-10-142

Gives increased precision at high-x

HERAPDF1.5 NLO is on LHAPDF5.8.6

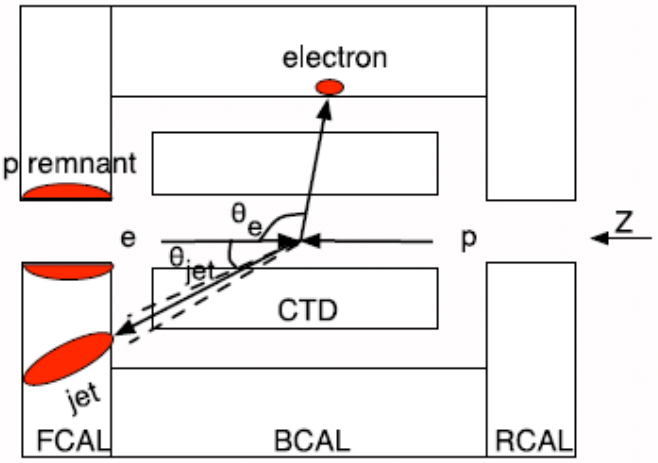
ZEUS-prel-11-004



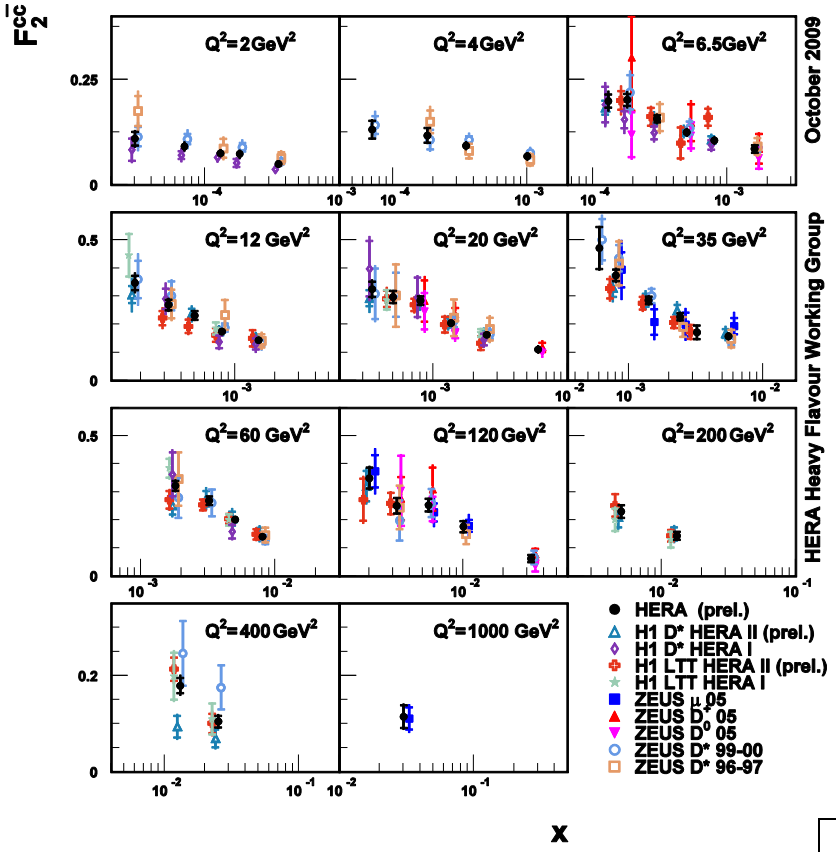
There is also an extension of the ZEUS data to high-x

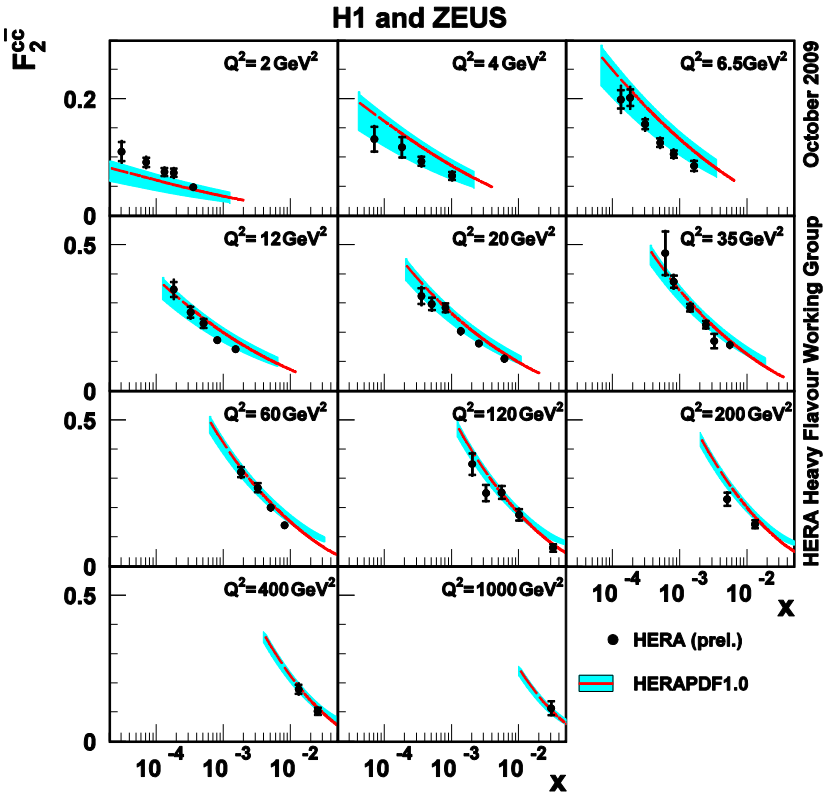
Experimentally very challenging region
- scattered electron has very poor x resolution
- hadronic final state enters forward beam pipe

Use jets for x reconstruction (not complete hadronic final state)
Use jet angle and pT of electron
Improves x resolution



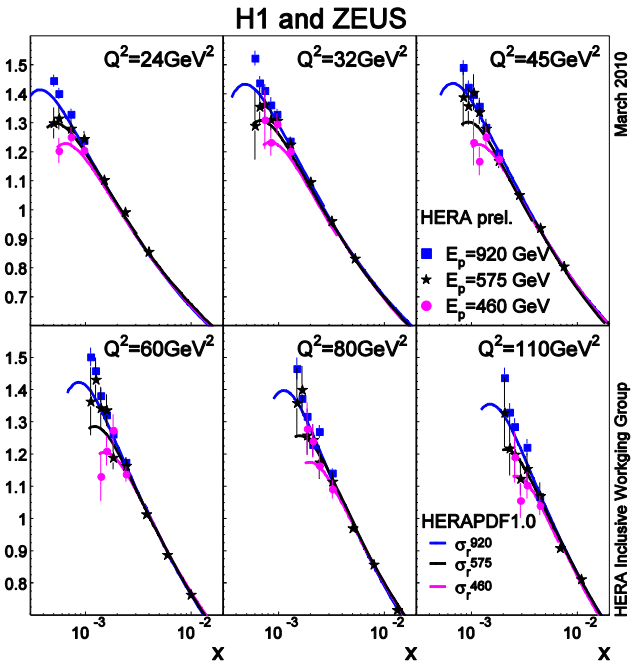
We have also combined HERA F2charm data (ZEUS prel 09- 015,H1prelim 09 -171)
Still preliminary!

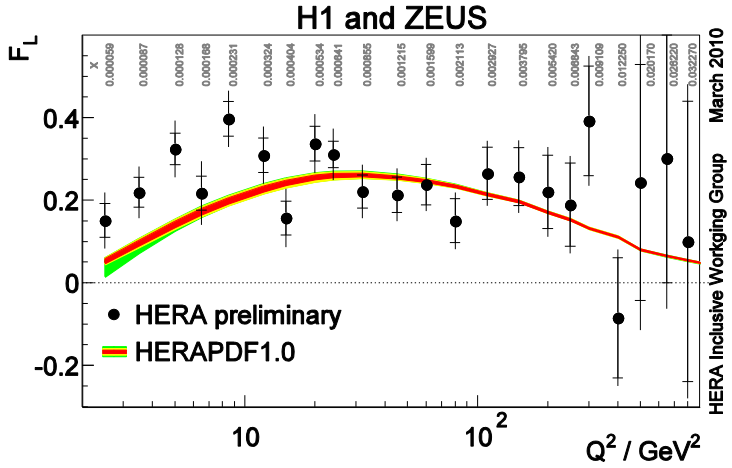




And the HERAPDF1.0 gives a good description of these charm data –within its error band- which spans m_c=1.35 (high) to m_c=1.65 (low) GeV

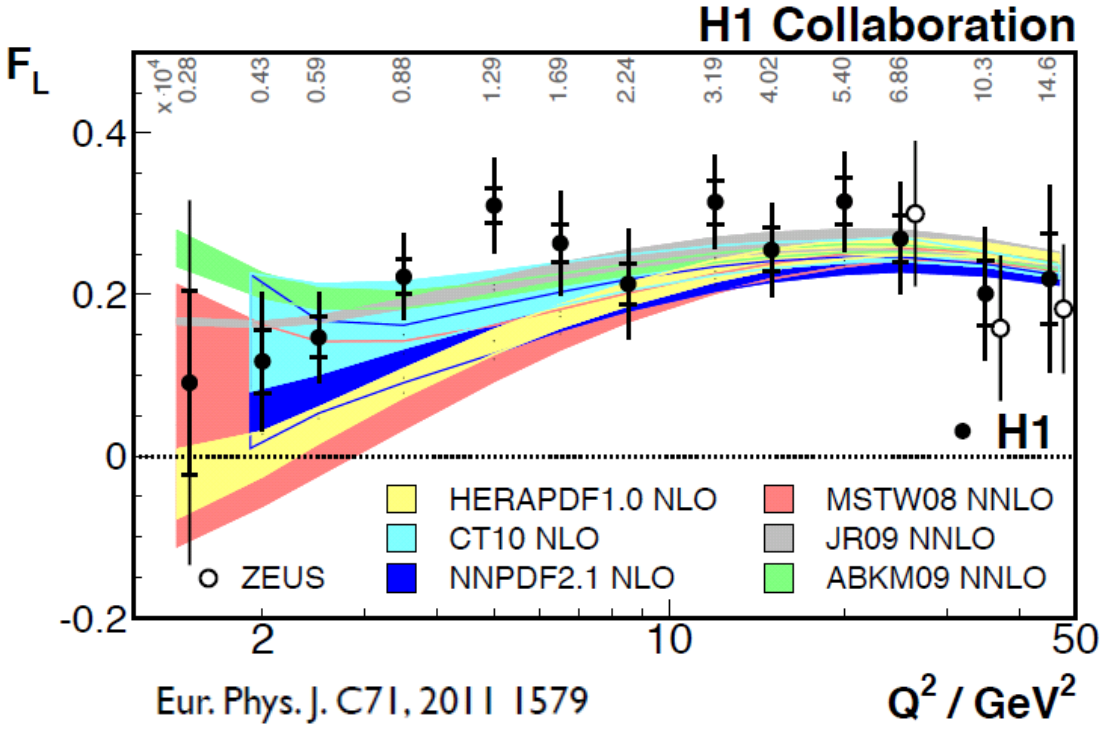
H1 and ZEUS have also combined the e+p NC inclusive data from the lower proton beam energy runs (P_P = 460 and 575) (ZEUS prel 10-001 , H1prelim 10-043) and produced a common FL measurement.

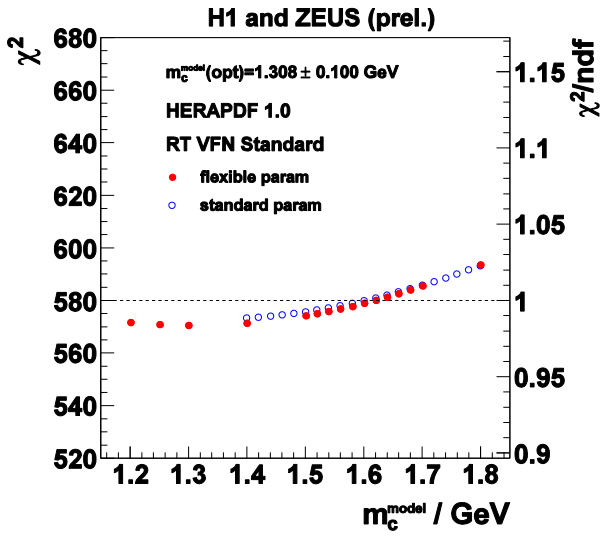


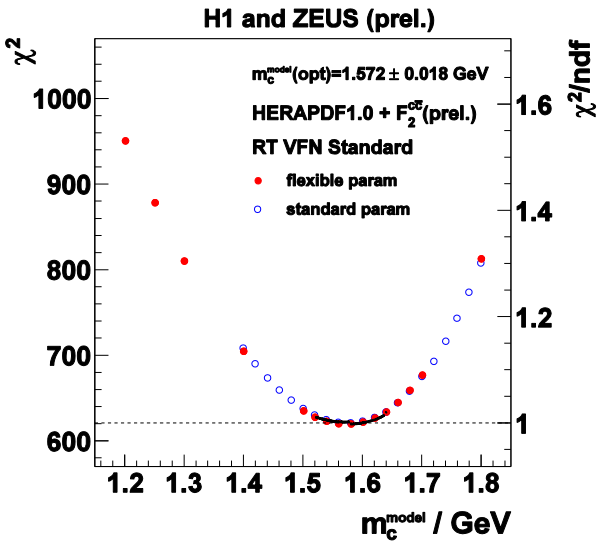


There is more data to go into this: notably the H1 extension to low Q^2

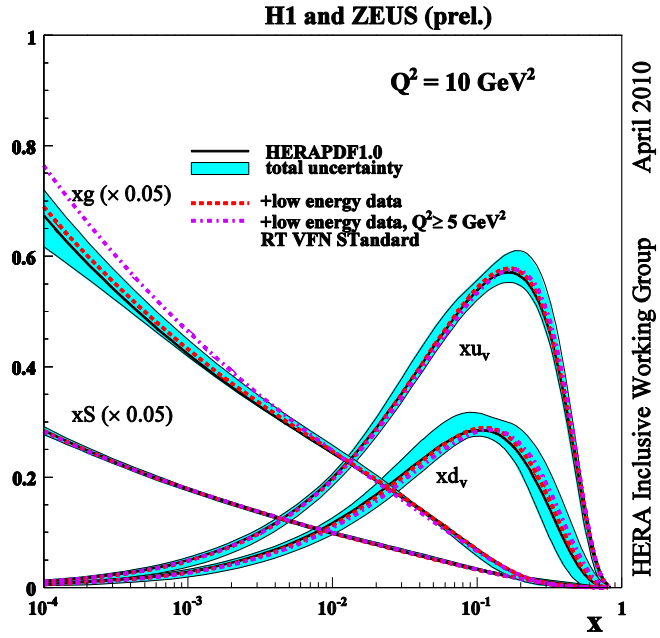
There is also as yet unpublished ZEUS data







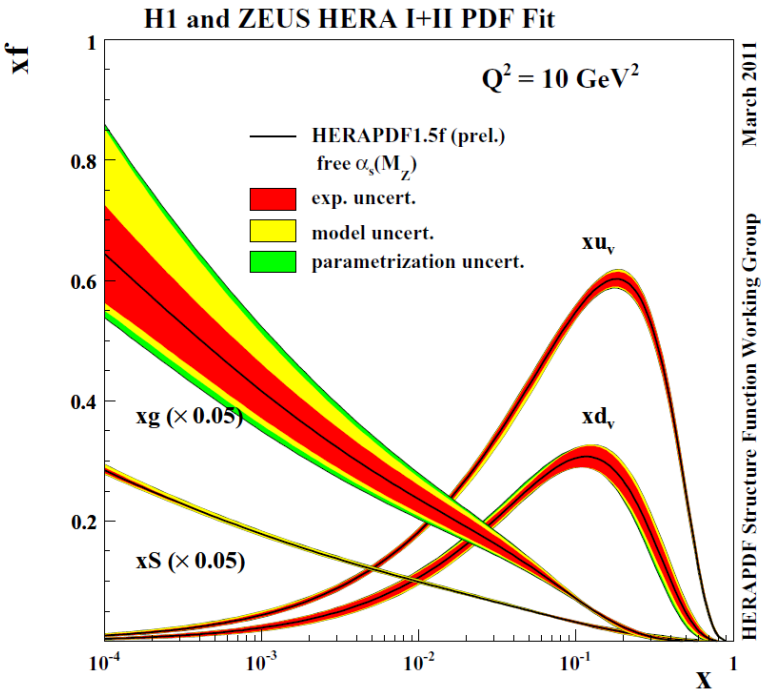
The combined charm data have sensitivity to mc
However the value depends on the scheme chosen to calculate the heavy quark contributions
The charm data will help to reduce uncertainties
ZEUS-prel 10-019
H1prelim-10-143



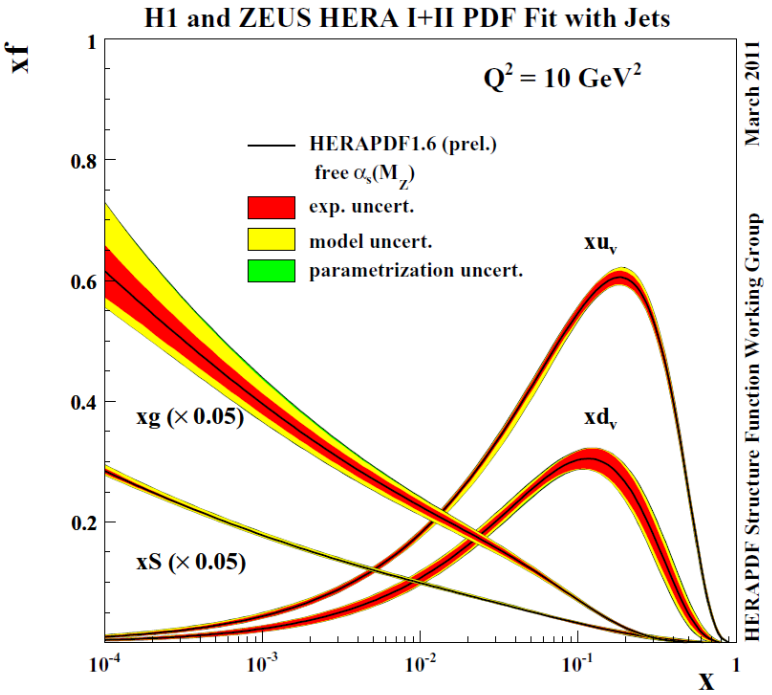
The combined low energy data are more sensitive to cuts on the low Q^2 - low x region.
This level of uncertainty is now covered by an extended parametrization with more flexibility in the low-x gluon and valence: as now used in HERAPDF1.5f, 1.6, 1.7 and 1.5NNLO
ZEUS-prel 10-009
H1prelim-10-045

We have added inclusive HERA jet data (as yet uncombined) at low and high Q2 to the fit: ZEUS-prel-11-001 H1prelim-11-034

And the jet data allow us to free $\alpha_S(M_Z)$: HERAPDF1.6



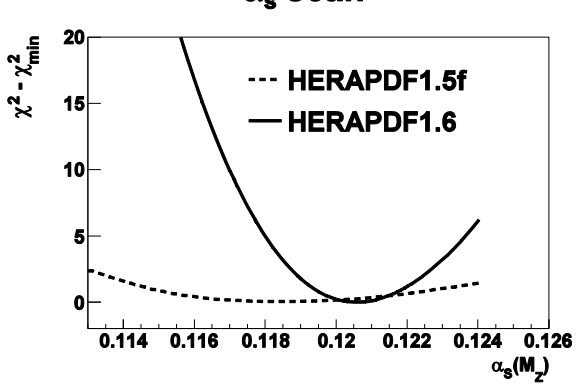
Free $\alpha_S(M_Z)$ no jets



Free $\alpha_S(M_Z)$ with jets

$\alpha_S(M_Z) = 0.1202 \pm 0.0019 \pm$ scale error~0.004

Larger than out default value of **$\alpha_S(M_Z) = 0.1176$**



LO

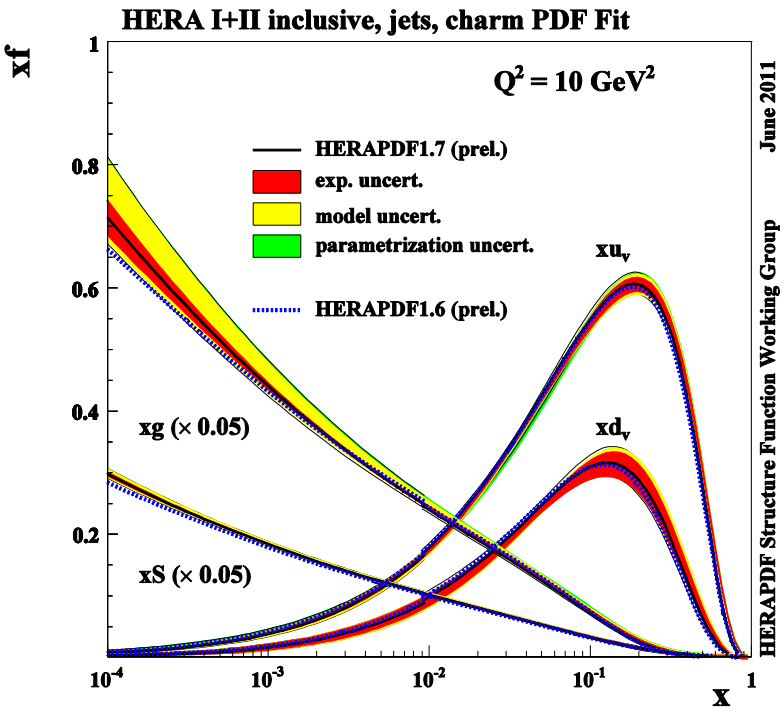
We have now put together all the data sets: HERAPDF1.7

HERA –I +II high energy inclusive, HERA-II low energy inclusive , F2charm and the separate H1 and ZEUS jet data to make HERAPDF1.7 NLO using the extended parametrization.(ZEUS prel-11-010)

All the data sets are very compatible and

•the addition of charm motivates us to change our standard VFN to the RT optimised version, with its preferred value of the charm mass parameterr mc=1.5 GeV,

•whereas the jet data motivate us to raise our standard NLO $\alpha_S(M_Z)$ value to $\alpha_S(M_Z) = 0.119$

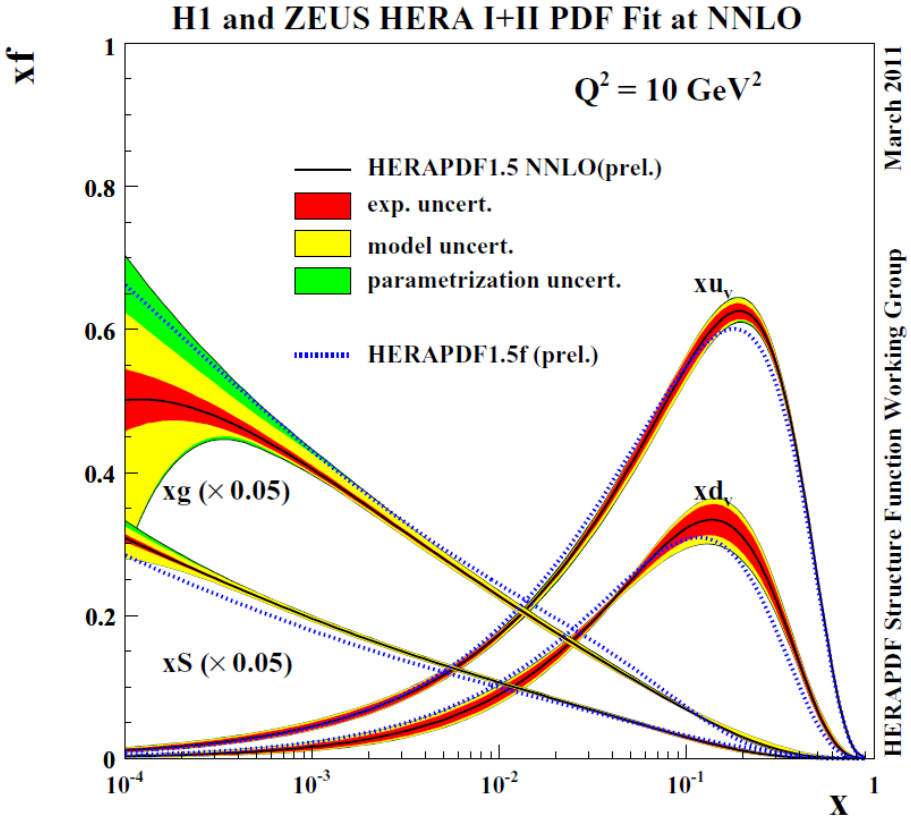


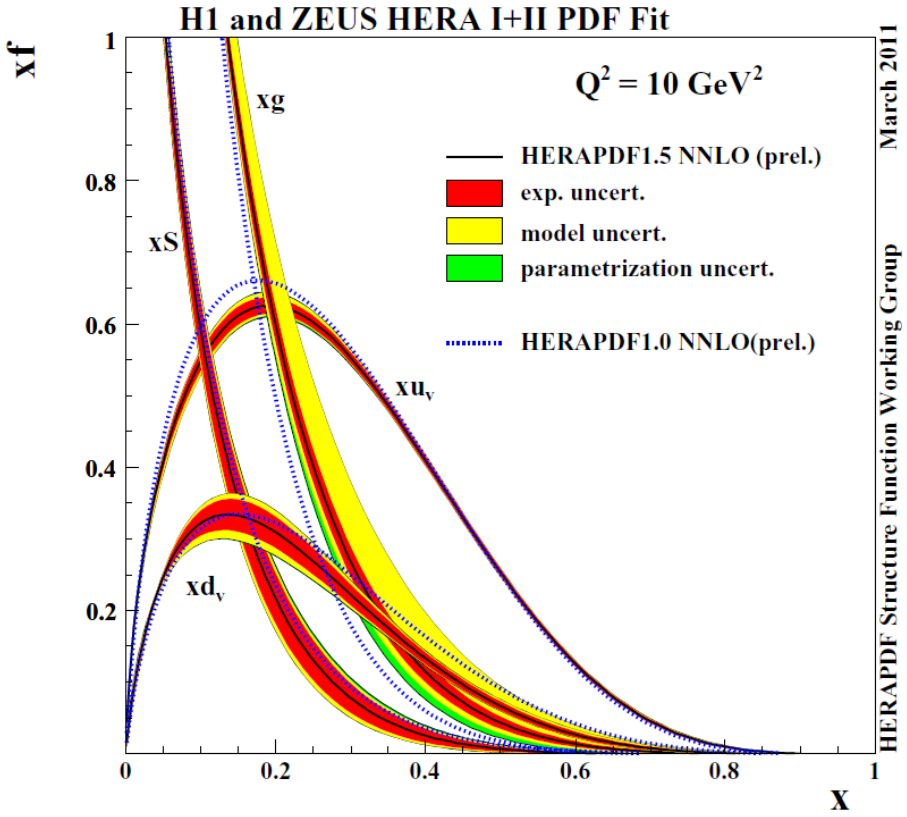
In view of the larger value of $\alpha_S(M_Z)$ at NLO we now recommend the larger value $\alpha_S(M_Z) = 0.1176$ for the central value for HERAPDF1.5 at NNLO.

For HERAPDF1.0 NNLO we had used both 0.1145 and 0.1176

And so to NNLO: ZEUS-prel-11-002/H1prelim-11-042

We use the more flexible form of the parametrisation and we use Thorne's NNLO VFN scheme.

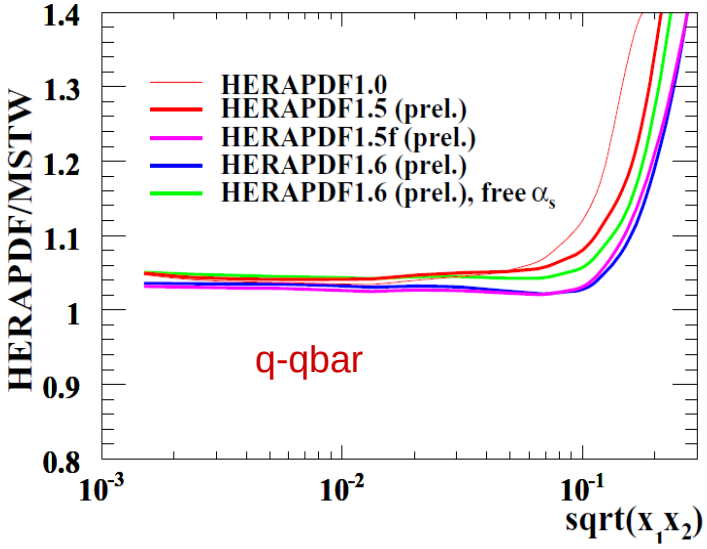


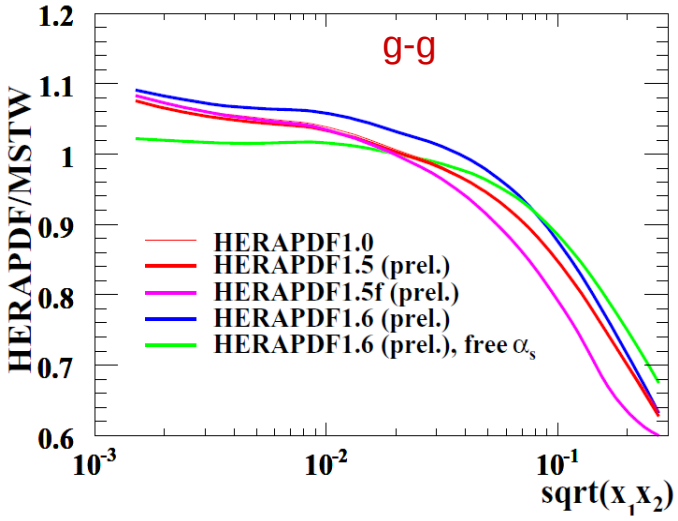


The low-x gluon has greater uncertainty than at NLO: NNLO DGLAP is NOT a better fit than NLO to low-x,Q^2 data

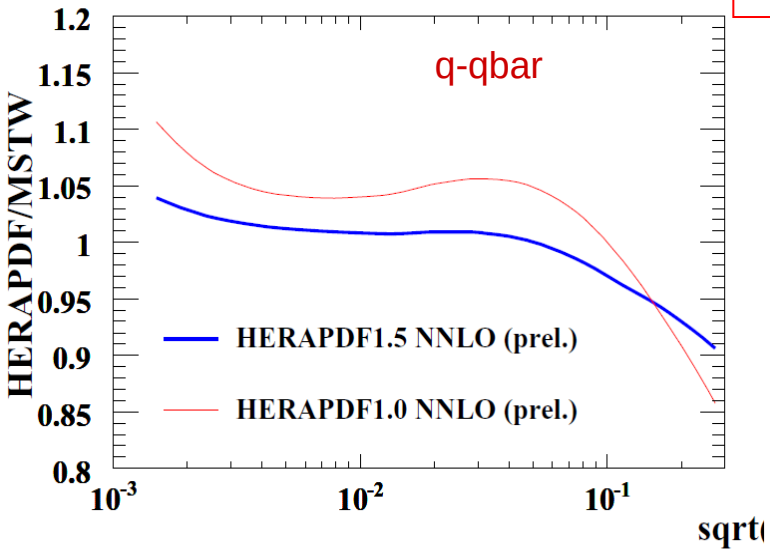
The first HERA NNLO analysis with accounting for PDF uncertainties is ready: HERAPDF1.5NNLO is on LHAPDF5.8.6

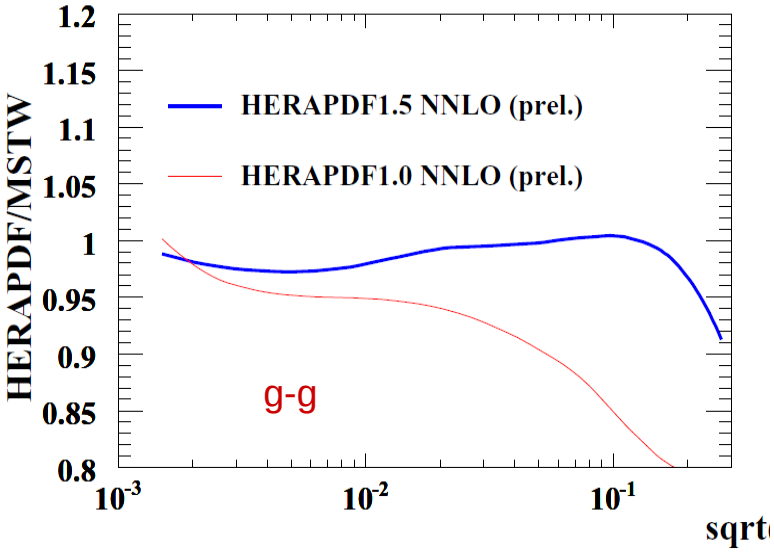
LHC at 7 TeV parton-parton luminosity plots for HERAPDF in ratio to MSTW2008 at NLO and NNLO





Benchmark updating





Benchmark updating

7 TeV cross sections

HERAPDF1.5 NLO

process	σ	exp	model+	model-	para+	para-	$\alpha+$	$\alpha-$
$H(m = 120\text{GeV})$, pb	10.94	0.23	0.05	0.12	0.08	0.53	0.25	0.46
$H(m = 180\text{GeV})$, pb	4.15	0.10	0.02	0.05	0.04	0.24	0.08	0.16
$H(m = 240\text{GeV})$, pb	1.93	0.05	0.01	0.03	0.02	0.13	0.03	0.07
$t\bar{t}$, pb	143.88	3.84	1.90	2.10	2.31	8.75	0.72	2.14
W^-, nb	39.48	0.27	1.01	0.17	0.76	0.18	0.00	0.41
$W^- \times Br_{\ell\ell}$, nb	4.260	0.030	0.110	0.020	0.080	0.020	0.000	0.044
W^+, nb	57.75	0.55	1.38	0.41	0.94	0.25	0.53	0.63
$W^+ \times Br_{\ell\ell}$, nb	6.240	0.060	0.150	0.040	0.100	0.030	0.057	0.068
Z, nb	28.98	0.29	0.73	0.08	0.54	0.15	0.23	0.36
$Z \times Br_{\ell\ell}$, nb	0.975	0.010	0.024	0.003	0.018	0.005	0.008	0.012

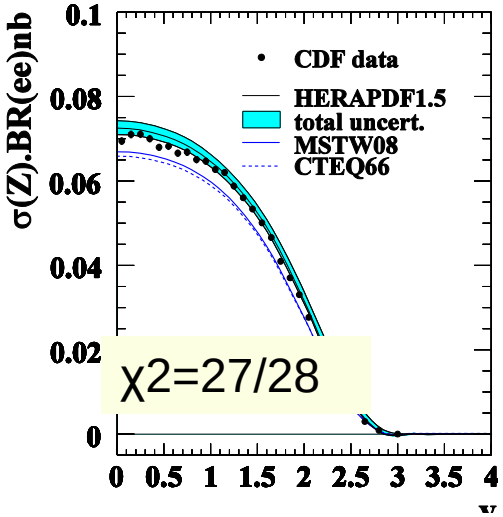
HERAPDF1.5 NNLO

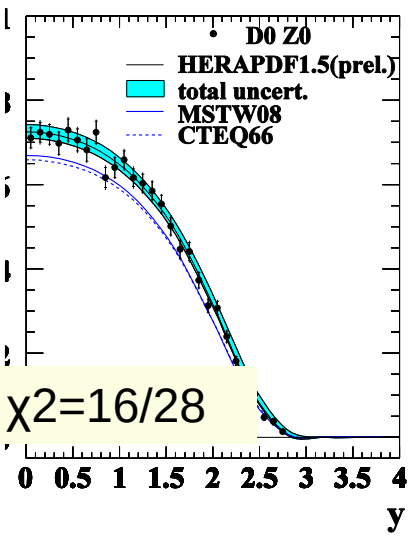
process	σ	Exp+	Exp-	Tot+	Tot-
W-. BR	4.404	0.058	0.038	0.148	0.049
W+.BR	6.345	0.107	0.080	0.228	-0.121
Z.BR	0.975	0.013	0.011	0.037	-0.015

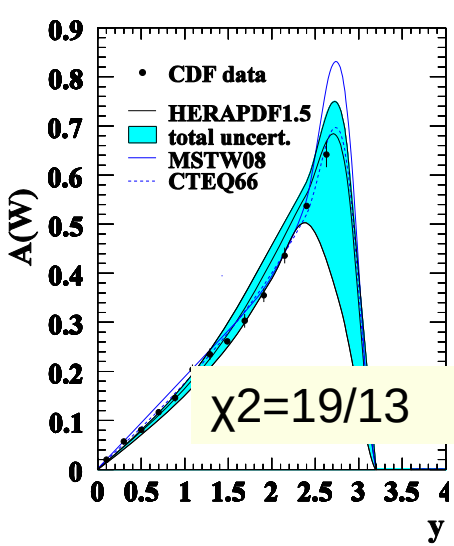
Total means experimental +model +param in quadrature

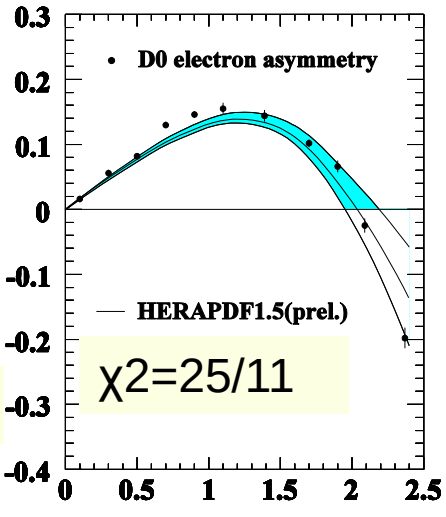
NNLO done with FEWZ2.1 with G_μ scheme and SM predictions for widths

Confronting HERAPDF with Tevatron data

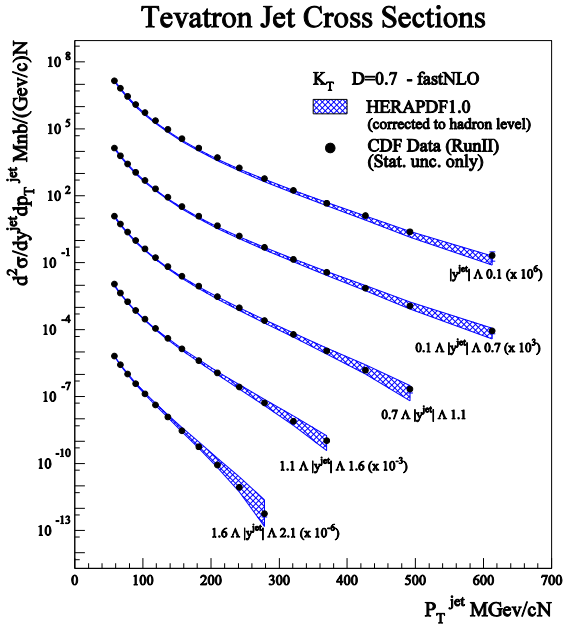








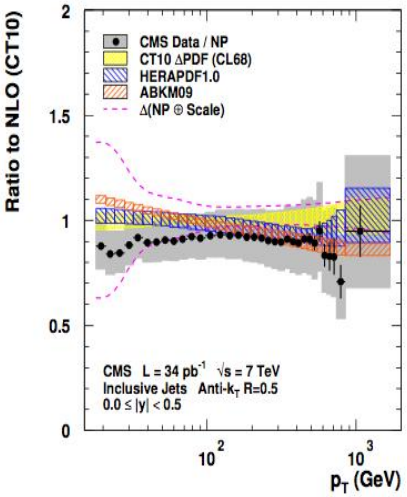
Pretty well for Tevatron W and Z data – even before fitting –and if these data are fit (χ2 given after fit) the resulting PDFs lie within the HERAPDF1.5 error bands

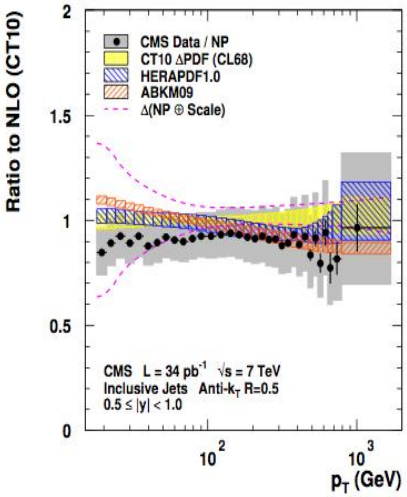


HERAPDF1.5 NLO central PDF fit to Tevatron jet data is not so great but if these data are input to the HERAPDF fit then χ2 are acceptable (χ2=113/76) and the resulting PDFs are still within the HERAPDF1.5 error bands

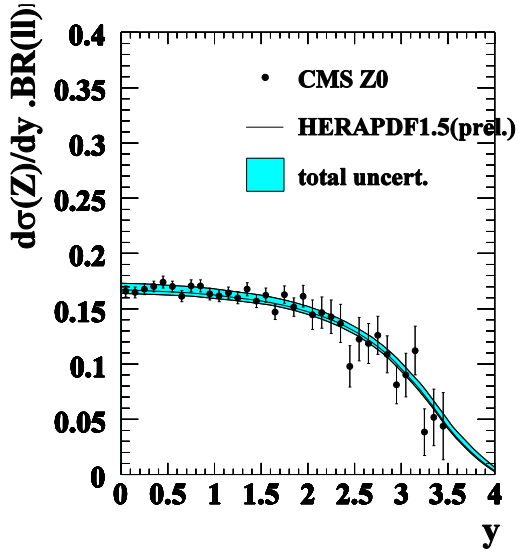
However, if we use HERAPDF1.5 NNLO PDFs to fit these jets data the description is MUCH better χ2/dp=72/76 for CDF even before the fit runs– ie HERAPDF1.5NNLO fits Tevatron jet data 'off the shelf'

Confronting HERAPDF with LHC data: CMS/LHCb

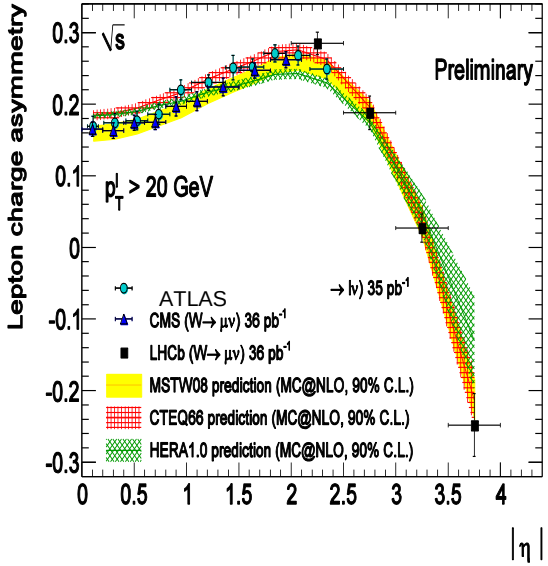




The CMS jet data are supplied with large uncorrelated systematics, since all we can do is add these in qudartaure we get small χ2 and the data are thus not discriminating



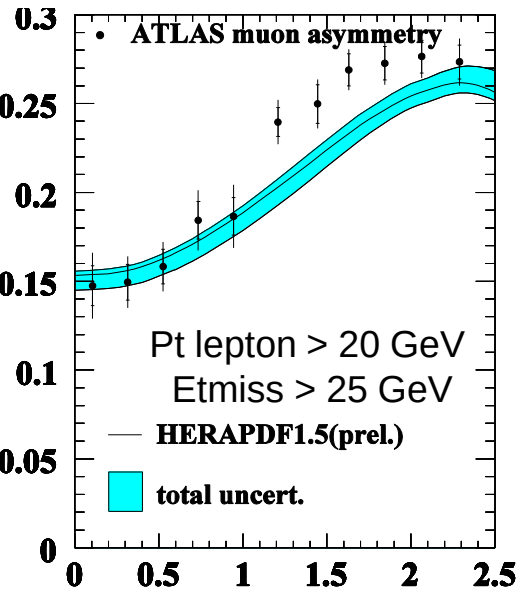
CMS Z0 data (very recent) are not precise enough to have significant PDF discrimination: HERAPDF1.5 χ2=18/35 and similar for CT10

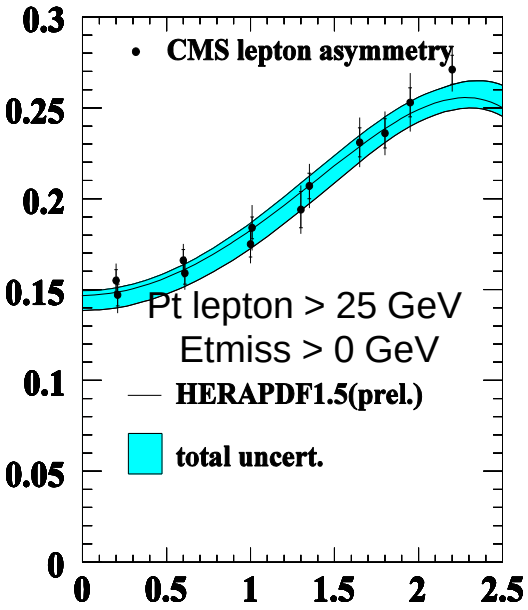


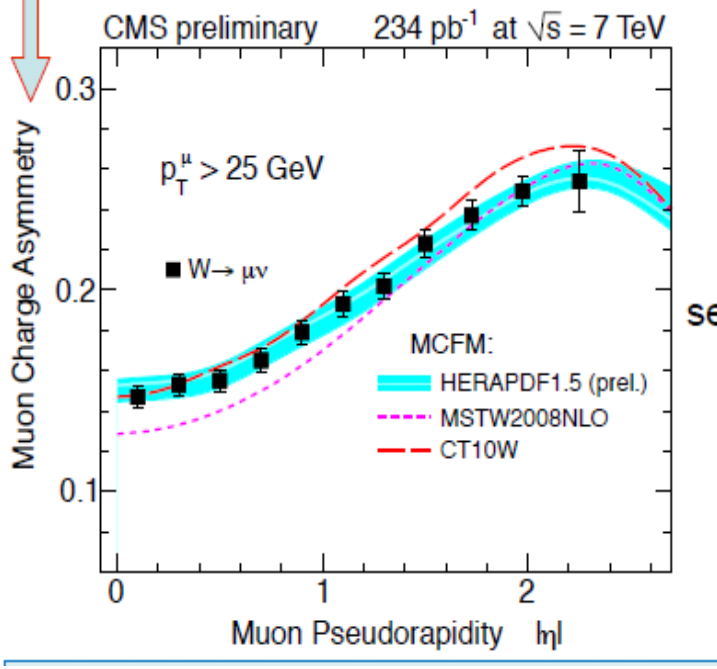
Joint ATLAS, CMS, LHCb W-lepton asymmetry plot done in common fiducial region, with MSTW08,CTEQ6.6 and HERAPDF1.0 illustrated

NOTE: nothing 'funny' at high rapidity= low-x

BUT this is already somewhat out of date….



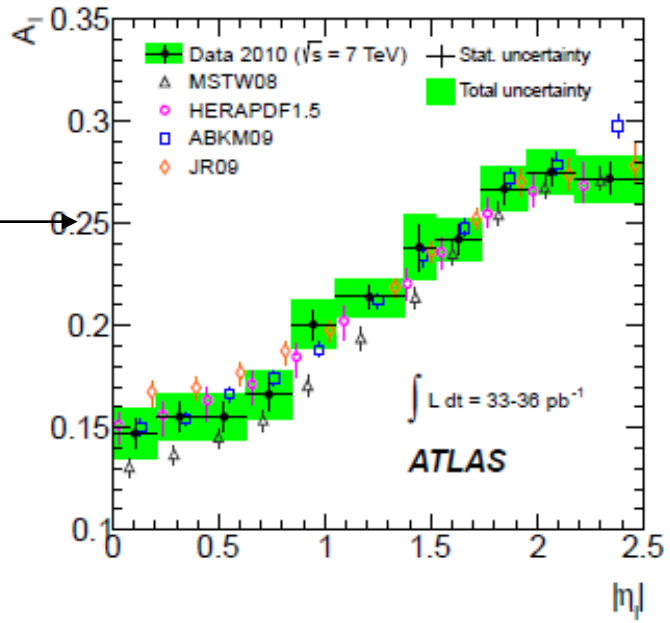




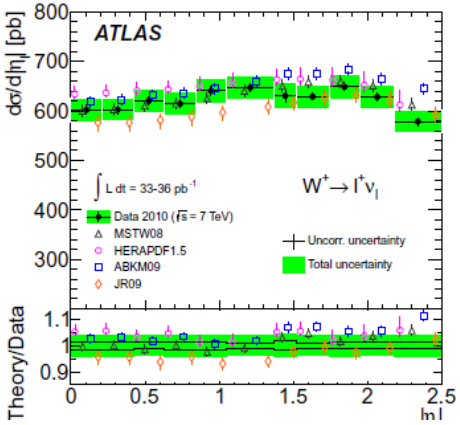
In March it looked as though ATLAS CMS 2010 asymmetry data pulled against each other.

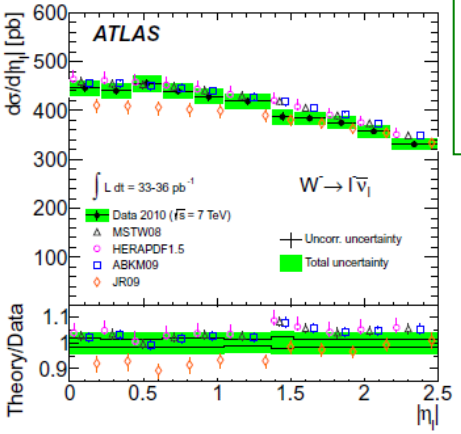
With the publication of ATLAS combined electron and muon data 2010

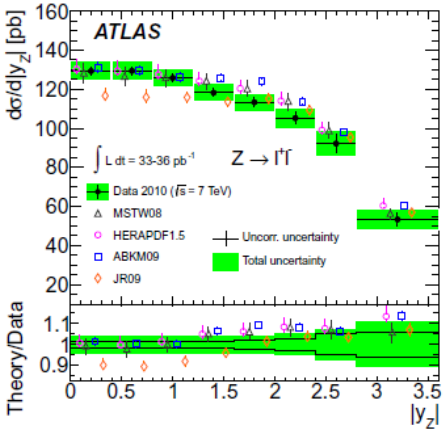
this is no longer an issue and there is also agreement with the 234pb^{-1} preliminary result of CMS



Confronting HERAPDF with LHC data: ATLAS

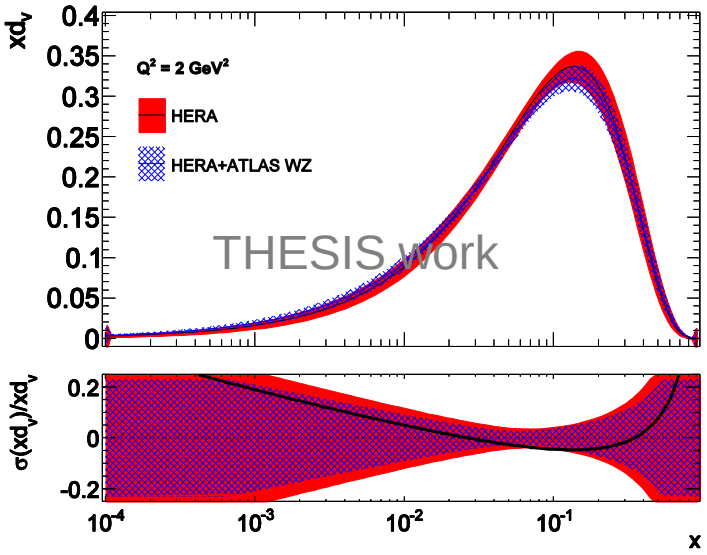






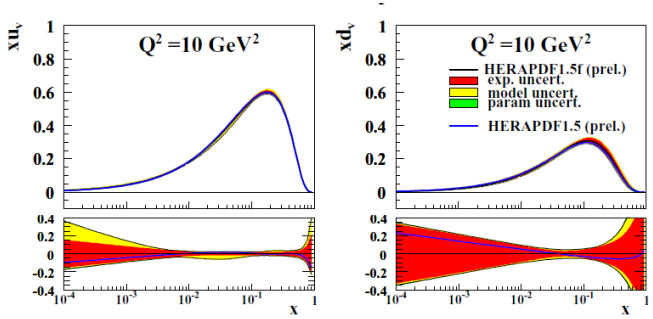
ATLAS W,Z data:- (arXiv:1109.5141) from 37pb-1 2010 data COMBINED electron and muon

And do these data change the PDF shapes or improve the uncertainties? Clearly there is beginning to be some PDF discrimination and if these data are fed into the HERAPDF1.5 NLO we get improvement in the d-valence uncertainties.

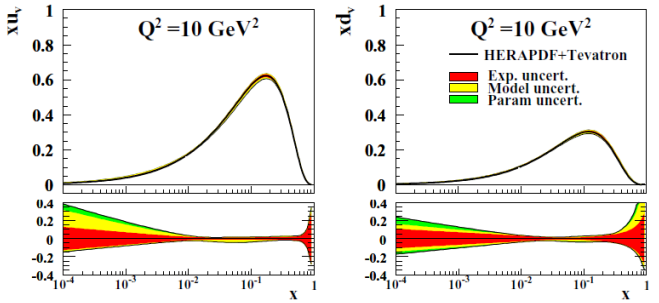


Thesis of S Whitehead, not official

BUT it does not really make sense to add these LHC data just to the HERAPDF, we need to see what improvement LHC data make in addition to the Tevatron data.



First add Tevatron W,Z data

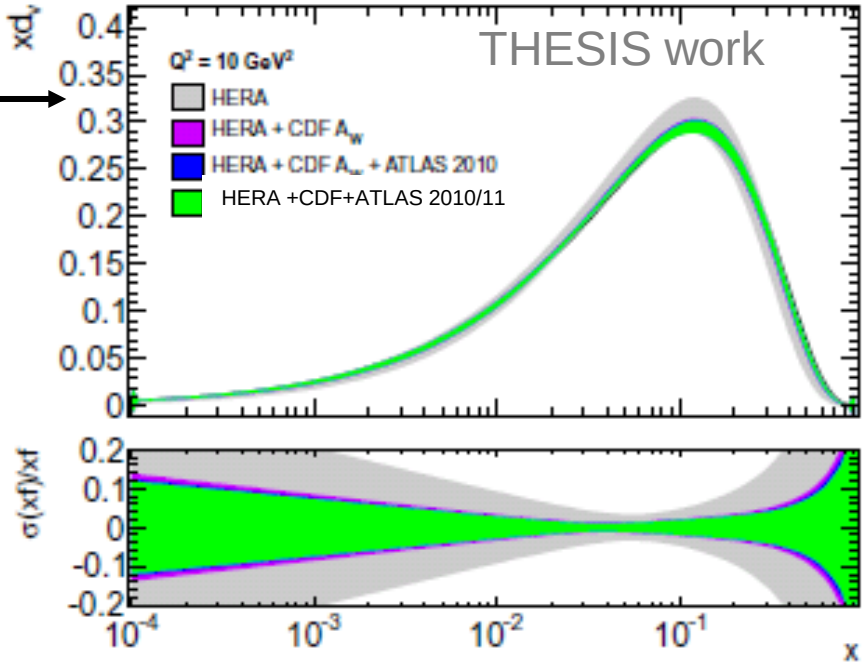


Comparison of HERAPDF1.5f to a fit to the same HERA data plus CDF Z0 and W-asymmetry data, taking into account model and parametrisation uncertainties

Now add ATLAS data 2010. Thesis work of S Whitehead (hence NOT official)

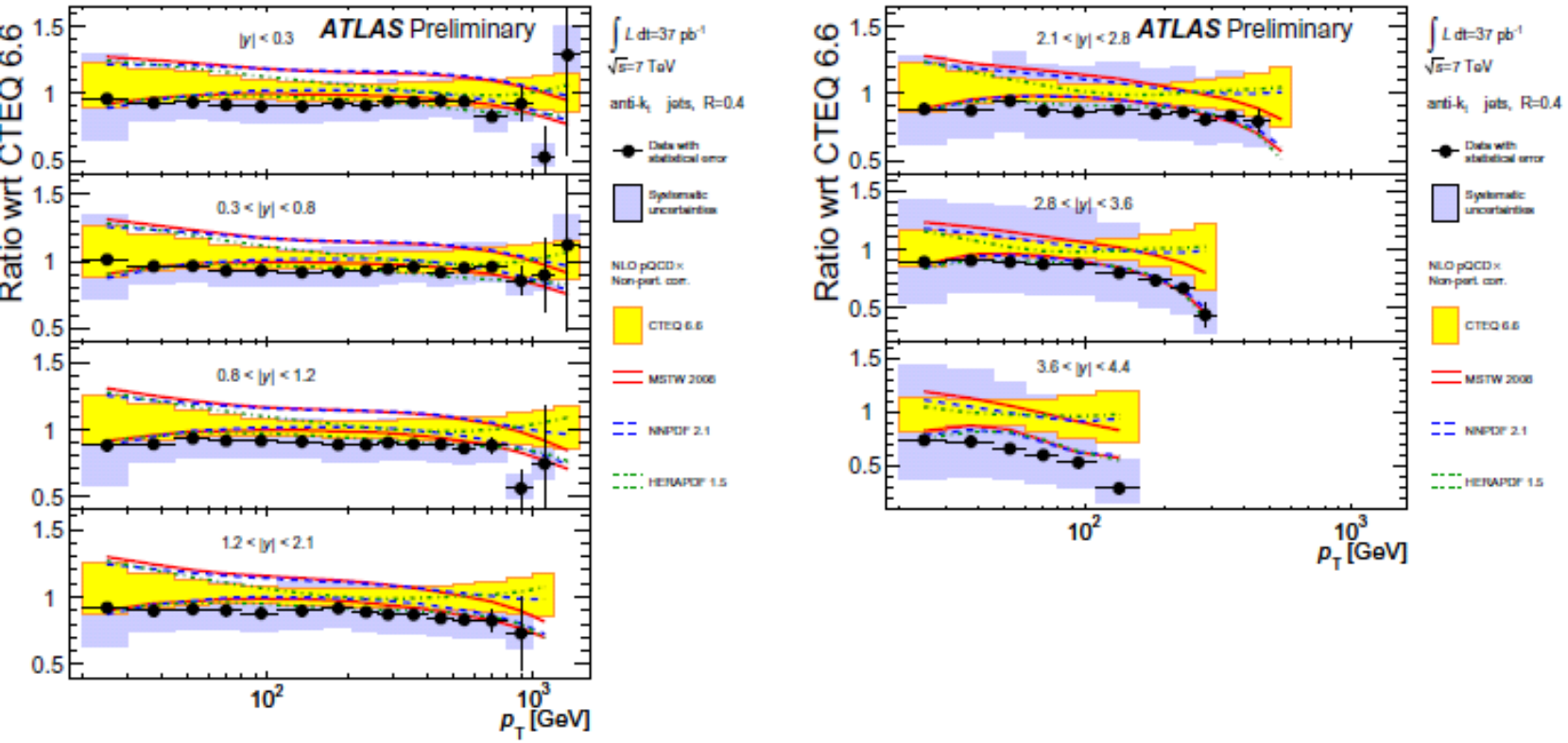
The LHC data reaches kinematic regions that the Tevatron could not reach.

There is some small additional improvement:



Potential impact of jet data

Add ATLAS inclusive jet data:- from 37pb-1 2010 data



The systematic uncertainties on these data are large. If they are treated as uncorrelated- then the HERAPDF fit has an absurdly low $\chi 2$ ~17 for 90 data pts .Treatment of the correlations is under consideration for the final publication of these data.

Treatment of correlations is ~complete- see talk of C Doglioni

Summary: where are we going?

- Both collaborations are working HARD on the publications of the HERA-II inclusive data.
- This combination may also contain the high-x extension
- The charm combination paper is being prepared
- A low energy run combination is foreseen when the ZEUS data are final
- There is also F2b data that could be combined
- There is more jet data that could be used: di-jets and tri-jet data can contribute to $\alpha_S(M_Z)$
- Jet data combination is also foreseen
- The aim for HERAPDF2.0 (NLO and NNLO) is to use the final inclusive combination at high and low-energies, F2c and jet data.
- We confront our PDFs with Tevatron and LHC data successfully