HERA precision measurements and impact for LHC predictions

Voica Radescu
(Heidelberg Physikalisches Institut)
On behalf of the H1 and ZEUS Collaborations

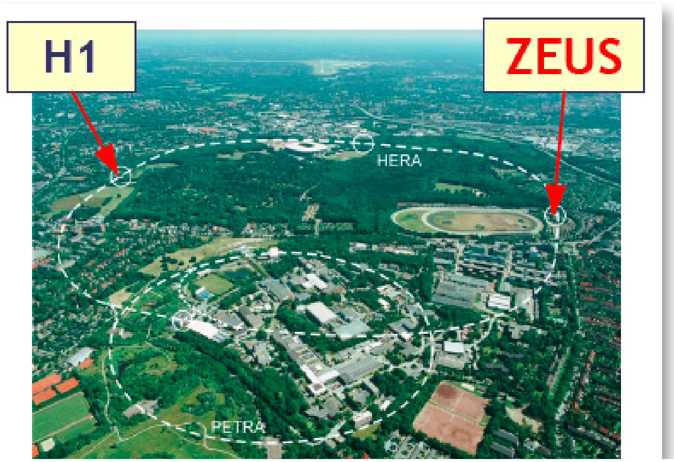
Rencontres de Moriond

March 2011

OUTLINE

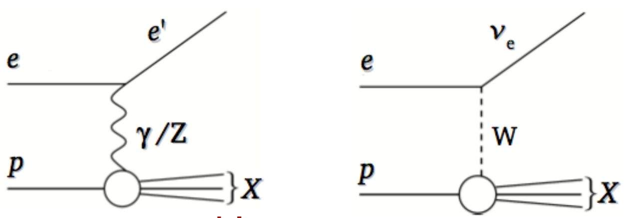
- HERA Experimental Settings
- HERA PDF analysis framework
- Results and Comparisons
- Predictions for Tevatron and the LHC
- Summary

HERA at DESY



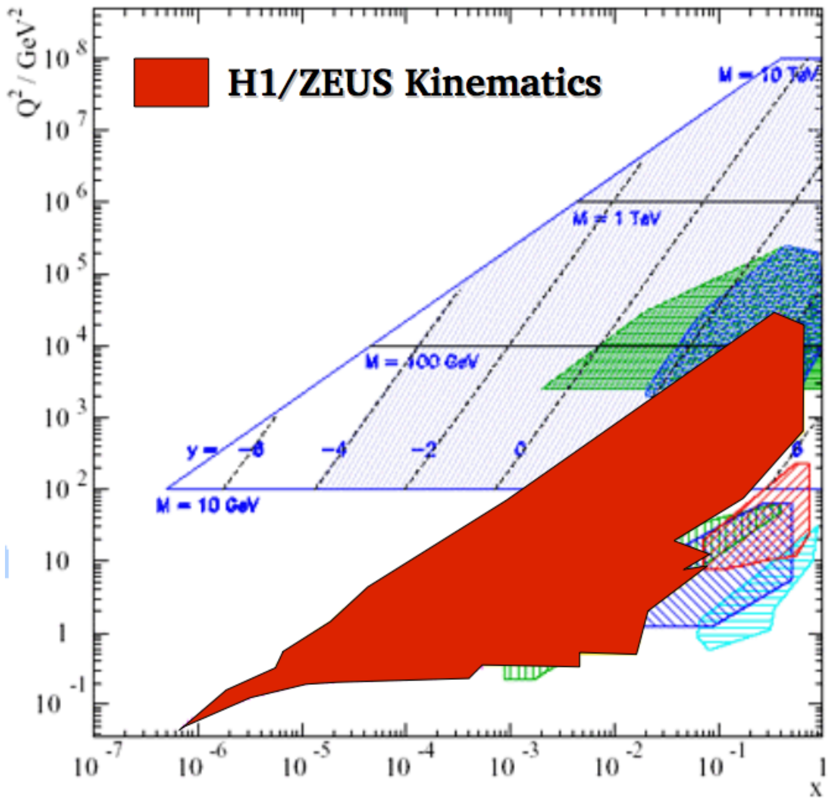
- HERA is world's only $e^{\pm}p$ collider
  - located at DESY, Hamburg - Germany
    - In operation for 15 years (1992-2007)
  - H1 and ZEUS collider experiments
    - General purpose detectors
    - ~$1fb^{-1}$ of integrated luminosity of physics data.
- HERA provides unique opportunity to study the structure of proton via DIS processes:

NC : $e\,p \rightarrow e'\,X$ CC : $e\,p \rightarrow \nu_e\,X$



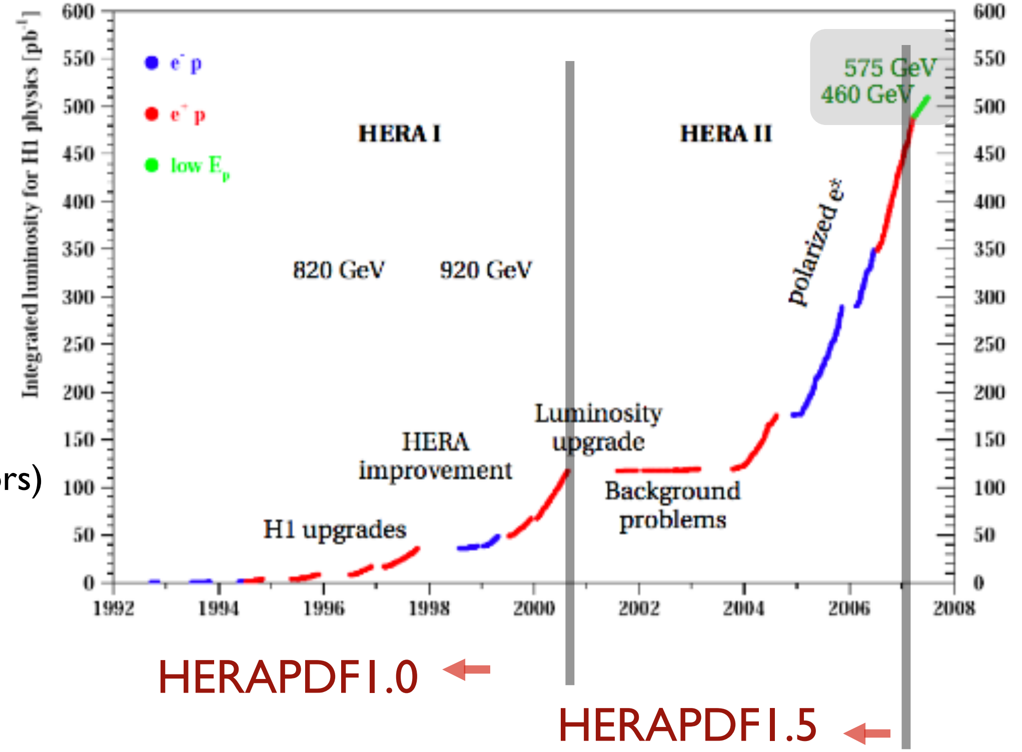
- Kinematic variables:
  - Virtuality of exchanged boson: $Q^2 = -q^2 = -(k - k')^2$
  - Bjorken scaling variable: $x = \frac{Q^2}{2p \cdot q}$
  - Inelasticity: $y = \frac{p \cdot q}{p \cdot k}$
  - Invariant centre of masss: $s = (k + p)^2 = \frac{Q^2}{xy}$

HERA-I	1992-2000	Ep=820,920 GeV
HERA-II	2003-2007	Ep=920, 460,575 GeV



Input Data from HERA into the HERAPDF fits

- Combined HERA I inclusive data
  [JHEP01(2010) 109]
  - HERAPDF1.0 NLO (full errors) and NNLO
  - Data used in NNPDF2.0(1), CT10, ABKM
- Combined HERA I+high Q^2 HERA II Data
  [prelim]:
  - Accurate measurements in high Q^2 region
    - Sensitivity to valence quarks
  - HERAPDF1.5 NLO, HERAPDF1.5f (full errors)
  - **NNLO (full errors)**
- H1 and ZEUS DIS Jet data:
  - HERAPDF1.6 NLO (full errors)
  - **Determination of strong coupling**
- Combined Charm F_2 data [prelim]:
  - Provides constraints on charm mass
  - Accounts for some differences among various PDF sets



- Low Energy Data HERA II [prelim]:
  - Accurate measurement in $Q^2 \geq 2.5$ GeV^2 range, sensitive to structure function F_L:
    - Investigate the low Q^2 region;
    - Test sensitivity to different heavy flavour treatments;

PDF determination at HERA

- General double differential cross section:

$$\frac{d^2\sigma^{\pm}_{NC}}{dx\,dQ^2} = \frac{2\pi\alpha^2}{xQ^4}\left[Y_+\tilde{F}_2 \mp Y_- x\tilde{F}_3 - y^2\tilde{F}_L\right] \equiv \frac{2\pi\alpha^2}{xQ^4} Y_+ \tilde{\sigma}^{\pm}_{NC}$$

$$Y_{\pm} = 1 \pm (1-y)^2$$

$$F_2 = x\sum e_q^2\,(q(x)+\bar{q}(x))$$

$$xF_3 = x\sum 2e_q a_q\,(q(x)-\bar{q}(x))$$

- F_2 dominates
  - sensitive to all quarks
- xF_3
  - sensitive to valence quarks
- F_L
  - sensitive to gluons

- Also, HERA CC data give flavour information

$$\sigma^{CC}_{e^+p} \sim x(\bar{u}+\bar{c}) + x(1-y)^2(d+s)$$ →Sensitive to d_v at large x

$$\sigma^{CC}_{e^-p} \sim x(u+c) + x(1-y)^2(\bar{d}+\bar{s})$$ →Sensitive to u_v at large x

QCD Fit settings:

- NLO (and NNLO) DGLAP evolution equations   QCDNUM package [M. Botje]
- RT-VFNS (as for MSTW08)
  - Other schemes were investigated as well: RT (optimal), ACOT (full and χ), FFNS

- PDF parametrised at the starting scale Q_0^2: $xg, xu_{val}, xd_{val}, x\bar{U} = x\bar{u}(+x\bar{c}), x\bar{D} = x\bar{d} + x\bar{s}(+x\bar{b})$
  - central fit with 10 free parameters (standard) - for HERAPDF1.0, HERAPDF1.5(NLO)

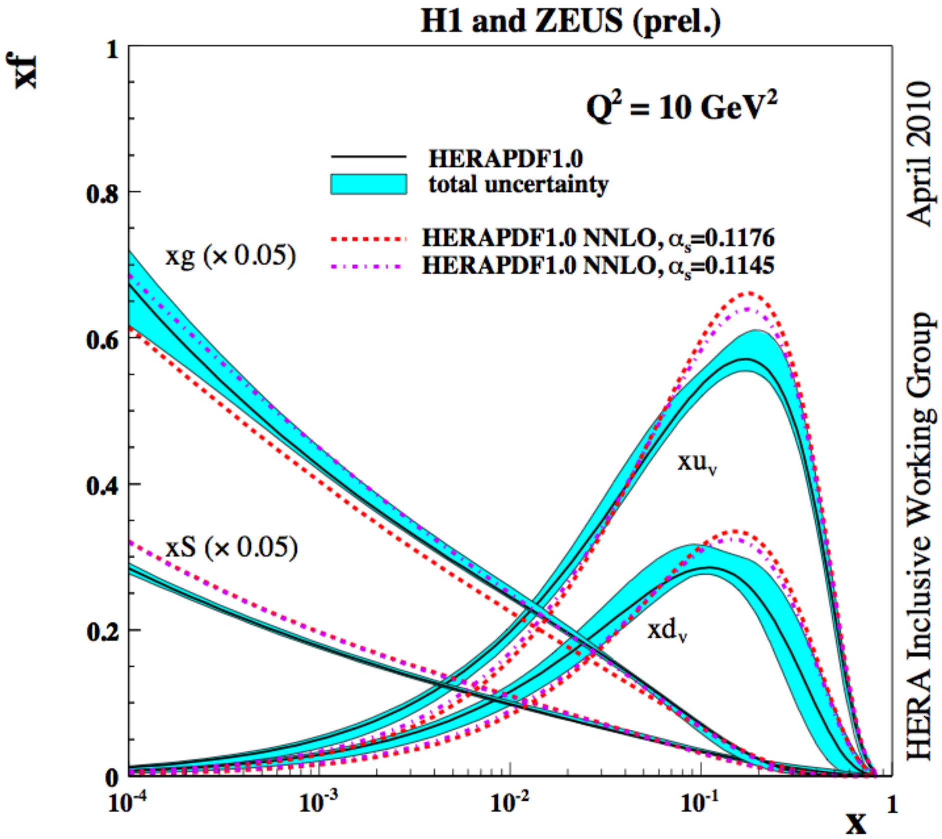
$$xf(x,Q_O^2) = Ax^B(1-x)^C(1+Dx+Ex^2)$$

  - central fit with 14 free parameters (flexible) - for HERAPDF1.5 NNLO and jet fits

$$xf(x,Q_0^2) = Ax^B(1-x)^C(1+Dx+Ex^2) - A'x^{B'}(1-x)^{25}$$

Results based on HERA I data: HERAPDF1.0 NNLO

- Fits performed to HERA I data at NNLO using RT-VFNS:
  - α_S(Mz) at NNLO = 0.1176 and α_S(Mz) at NNLO = 0.1145



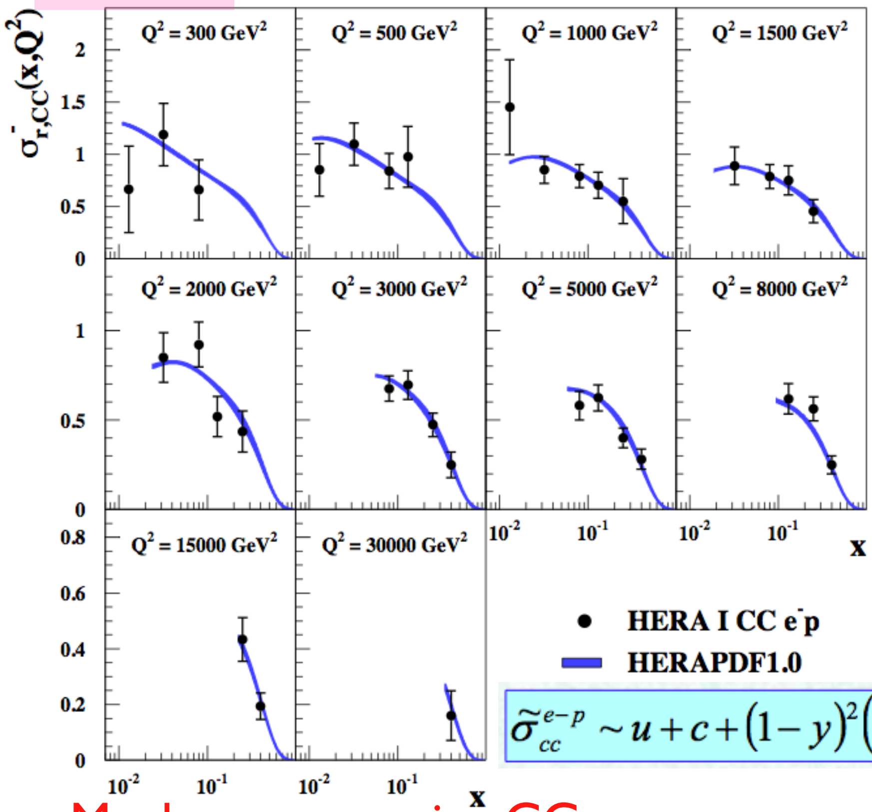
scheme	NNLO α_S(Mz)=0.1145	NNLO α_S(Mz)=0.1176	NLO α_S(Mz)=0.1176
All χ^2/dof	623.7/582	638.3/582	574.4/582

- Using the same parametrisation as for HERAPDF1.0, NNLO fit does not improve χ^2

Combining HERA I and II Inclusive data

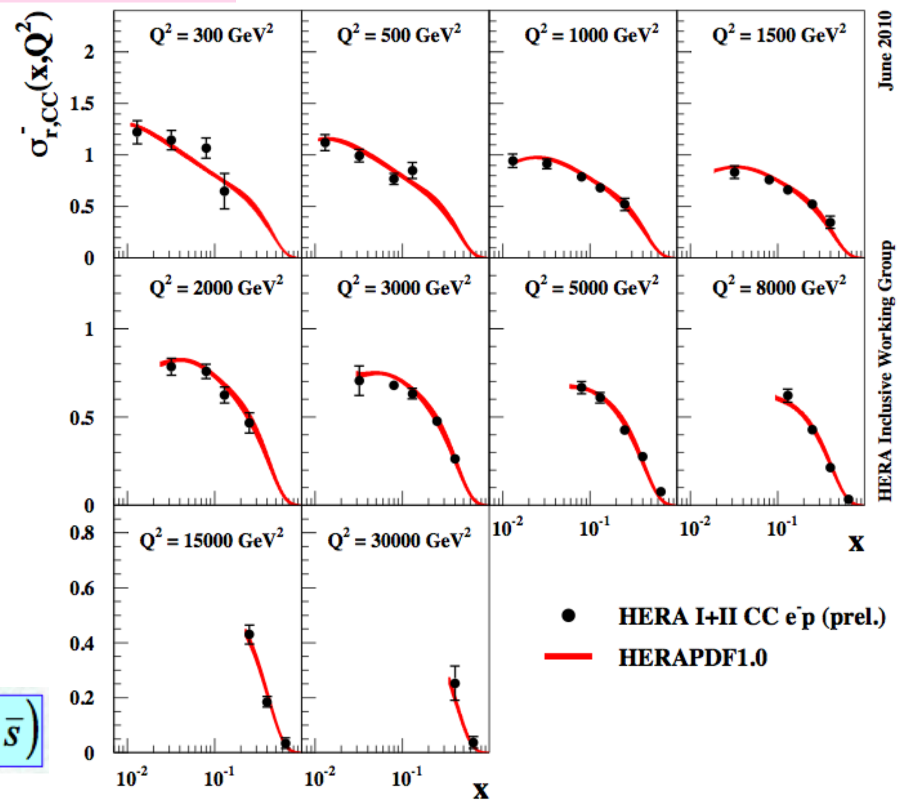
- New HERA II preliminary data used for HERAPDF fits
  - More precise measurements in the high Q^2 and large x regions (especially NC e^-p and CC $e^{\pm}p$)
  - ➔ constrains HERAPDFs at large x
- HERA I and HERA II data are combined using averaging procedure:
  - 674 unique cross sections points with 134 sources of systematic uncertainties

HERA I



$$\tilde{\sigma}_{cc}^{e-p} \sim u + c + (1-y)^2(\bar{d}+\bar{s})$$

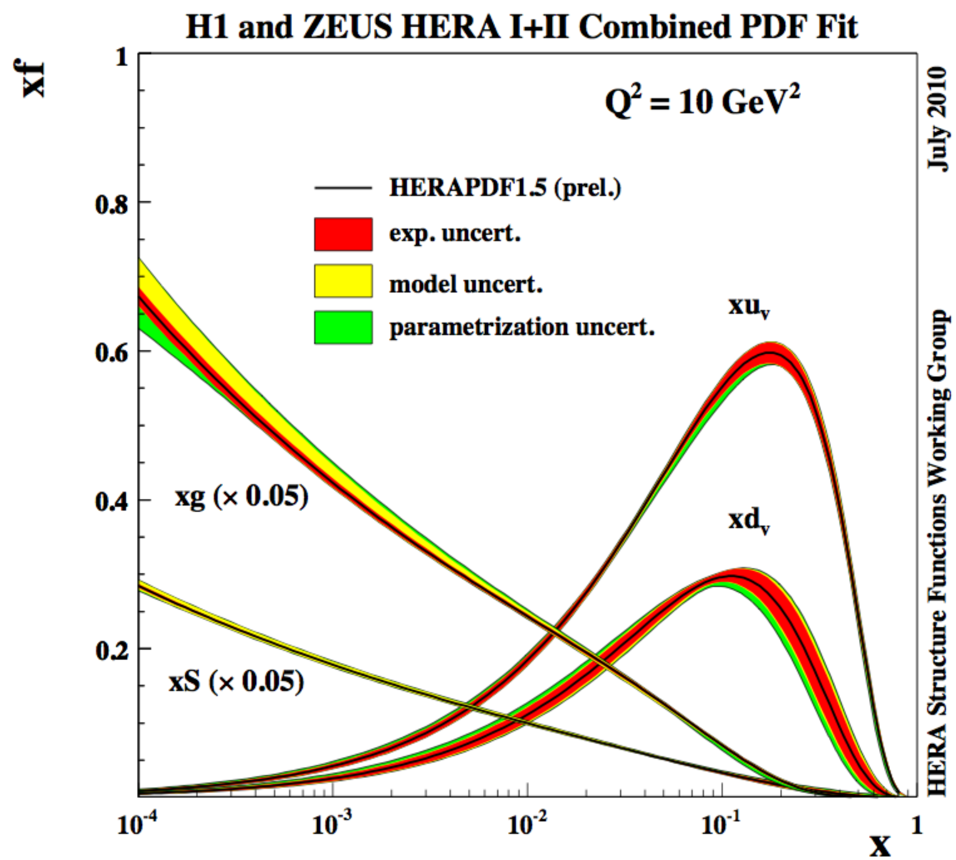
HERA I+II

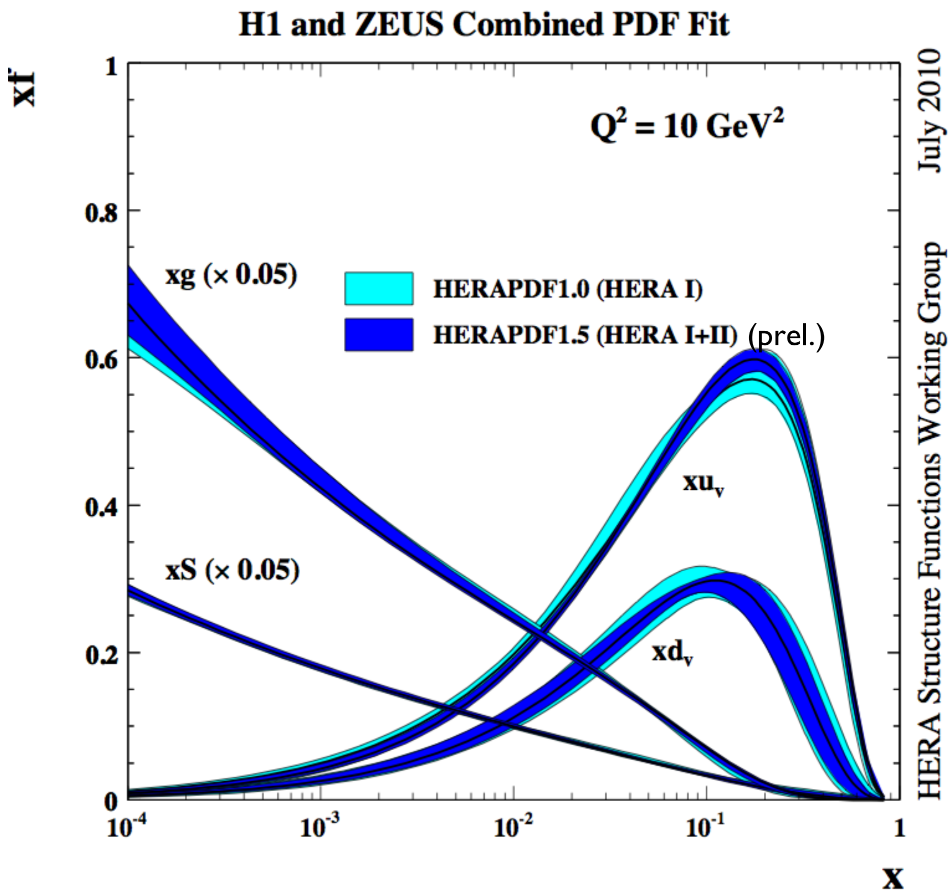


Much more precise CC measurements after including new high Q^2 HERA II set

Results based on HERA I+II data: HERAPDF1.5 (NLO)

- xg, xu_v, xd_v, xS ($xS=x\bar{U}+x\bar{D}$) at the scale Q^2=10 GeV^2



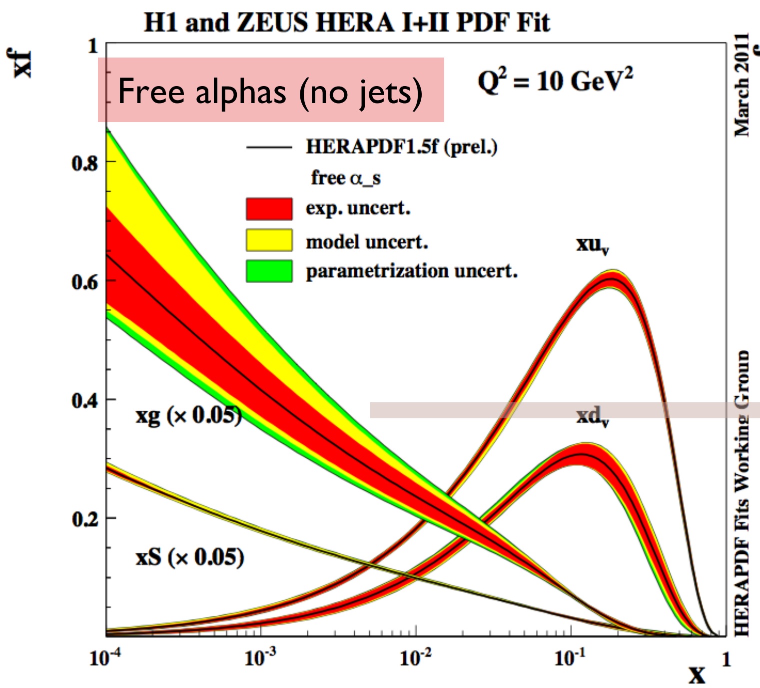


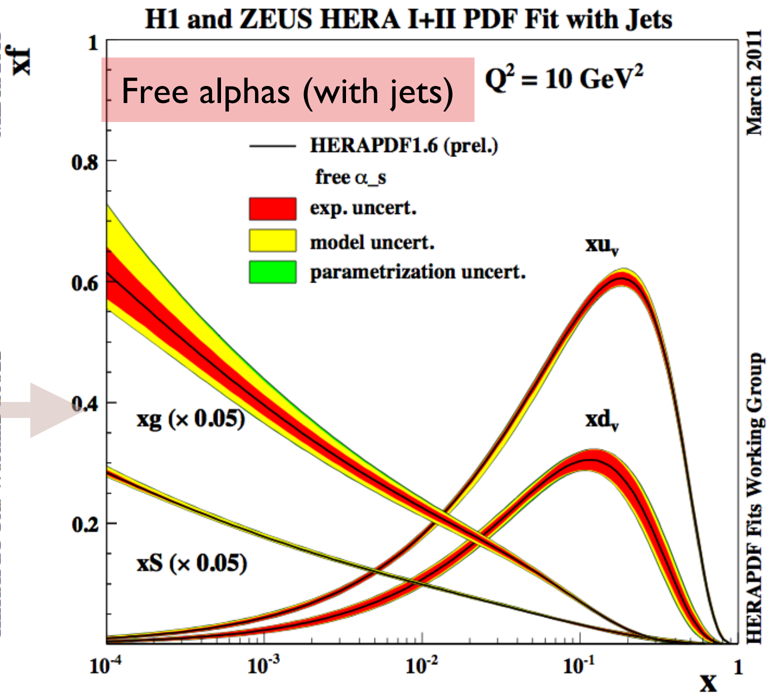
- Inclusion of the HERA II data reduces the uncertainties on PDFs in the high x region especially visible on the valence distributions!
    - See HERAPDF1.5(prel) vs HERAPDF1.0

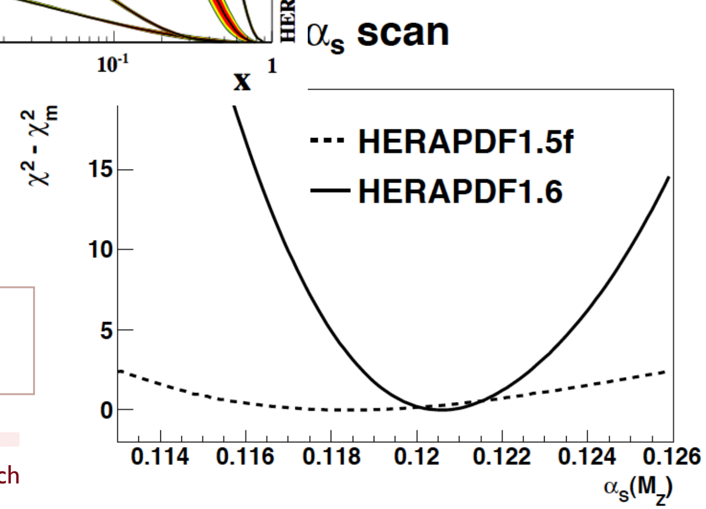
HERAPDF Fits including DIS Jets

- Addition of the HERA Jet cross section data (NLOJet++) into the fits allows to constrain simultaneously alphas and gluon:

  * Due to strong correlation between alphas and gluon, a more flexible parametrisation is used by adding extra terms for gluon and valence (14 parameters)







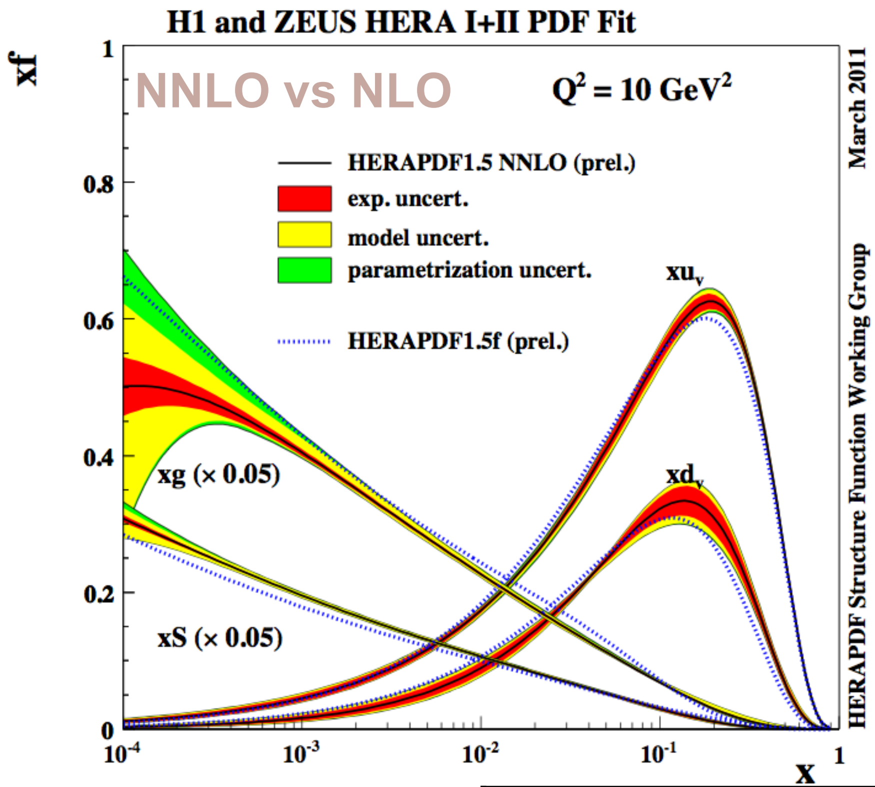
- HERA data prefer larger value for strong coupling:

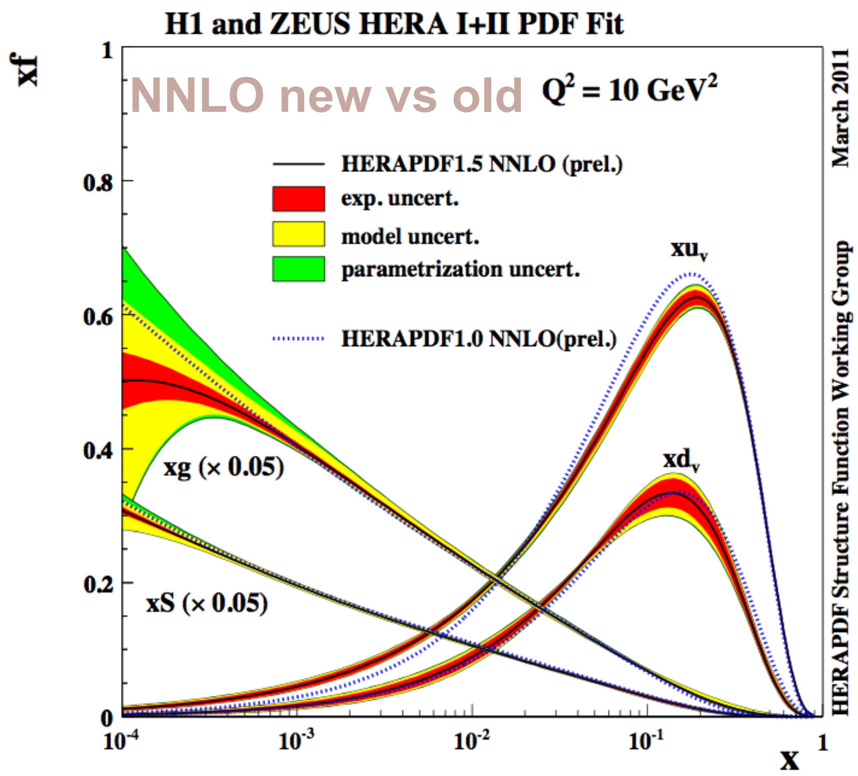
$$\alpha_s = 0.1202 \pm 0.0013\,(\exp) \pm 0.0007\,(mod) \pm 0.0012\,(had)\,^{+0.0045}_{-0.0036}\,(th)$$

Premiere!

Results based on HERA I+II data: HERAPDF1.5 (NNLO)

- Fits performed to HERA I data (as used for HERAPDF1.0) at NNLO using RT-VFNS:
  α_S(Mz) at NNLO = 0.1176



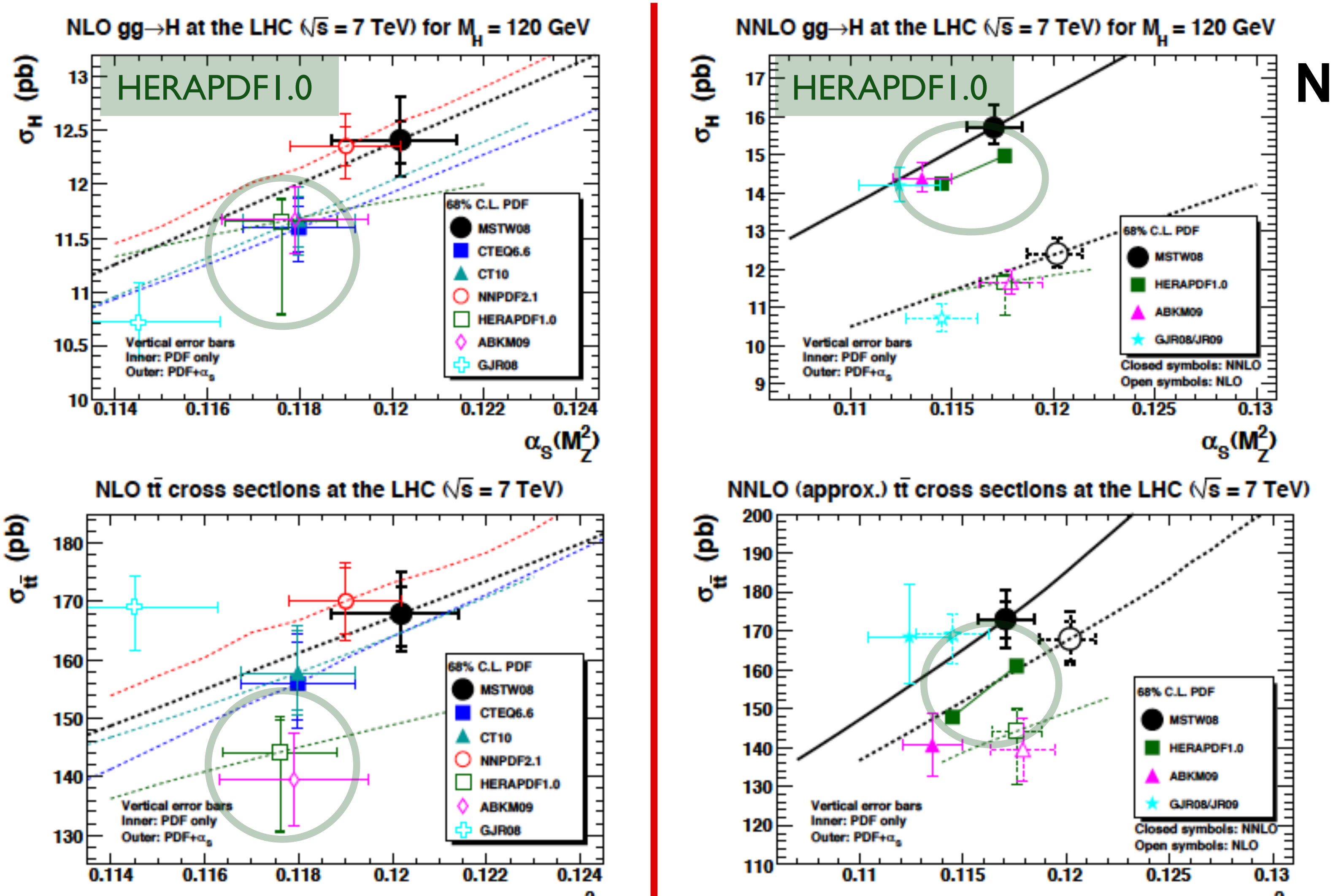


scheme	NNLO α_S(Mz)=0.1176	NLO α_S(Mz)=0.1176
All χ^2/dof	744.3/660	735.1/660

- HERAPDF1.5 NLO vs NNLO is in much better agreement than for HERAPDF1.0 case
  - use of a more flexible parametrisation for the central fit (10 parameters vs 14 parameters fit)
- HERAPDF1.5 NNLO vs HERAPDF1.0 NNLO yields a harder gluon and softer valence at high x

LHC predictions for Higgs and top cross sections

NLO **NNLO**

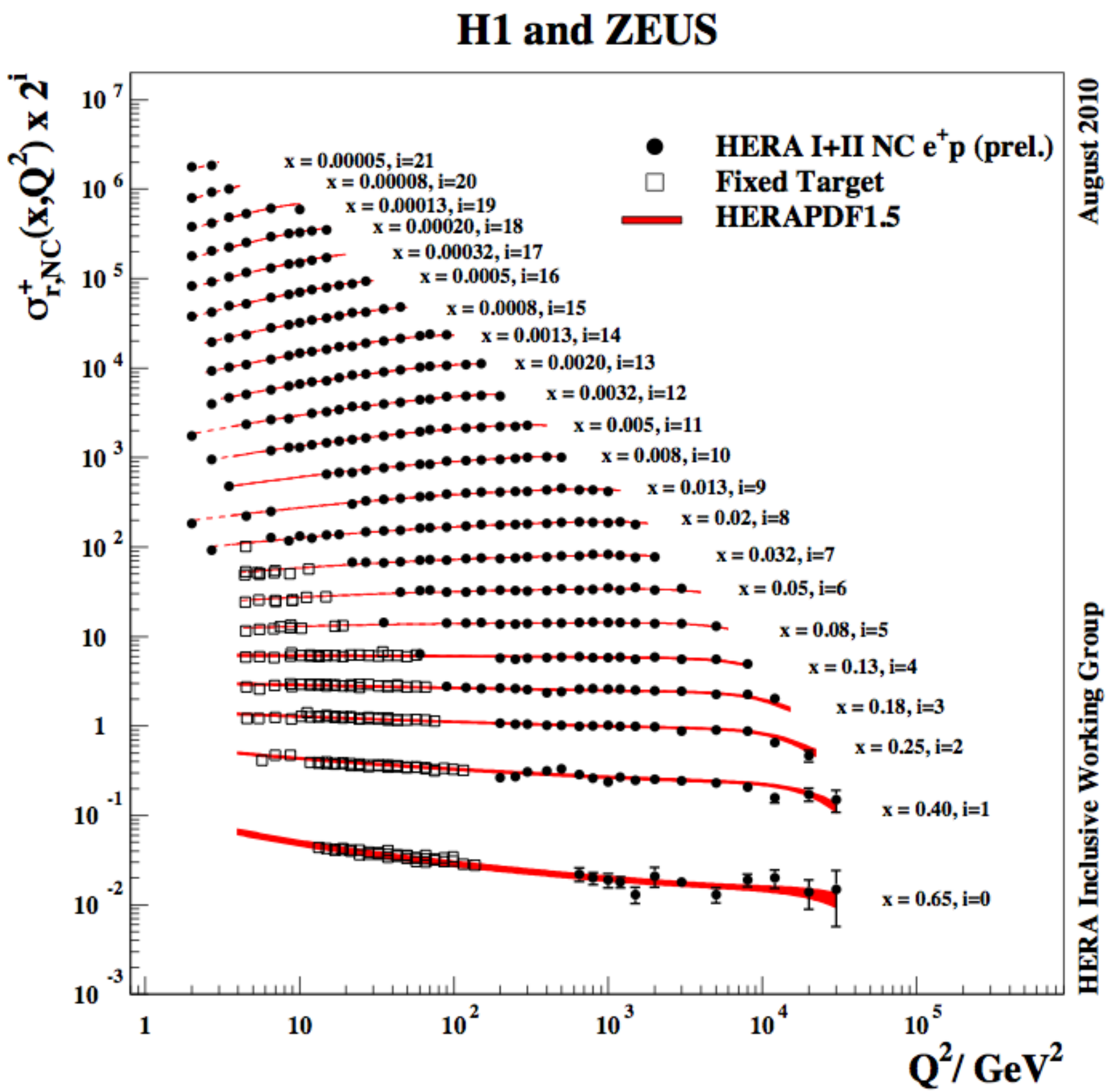


From G.Watt [PDF4LHC March 2011]

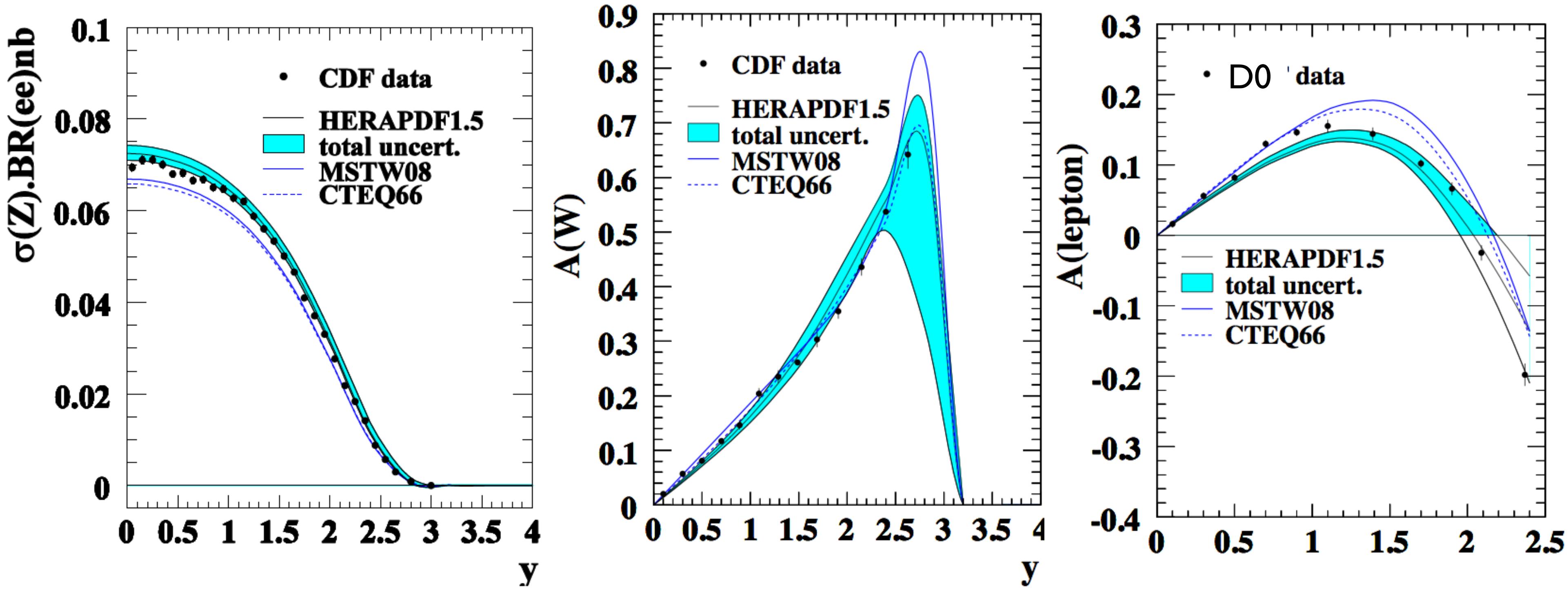
HERAPDF1.0 based solely on ep data provides a competitive prediction compared to global PDFs

HERAPDF1.5 (NLO) vs DIS Data

- Plots show the extended kinematic range of the HERA I and II data as compared to the fixed target measurements:
  - Data points include experimental uncertainty
  - Fit line includes total uncertainty
- HERAPDF1.5 fits describe our data well
- Extrapolation of the HERAPDF1.5 fits agree well with fixed target data.



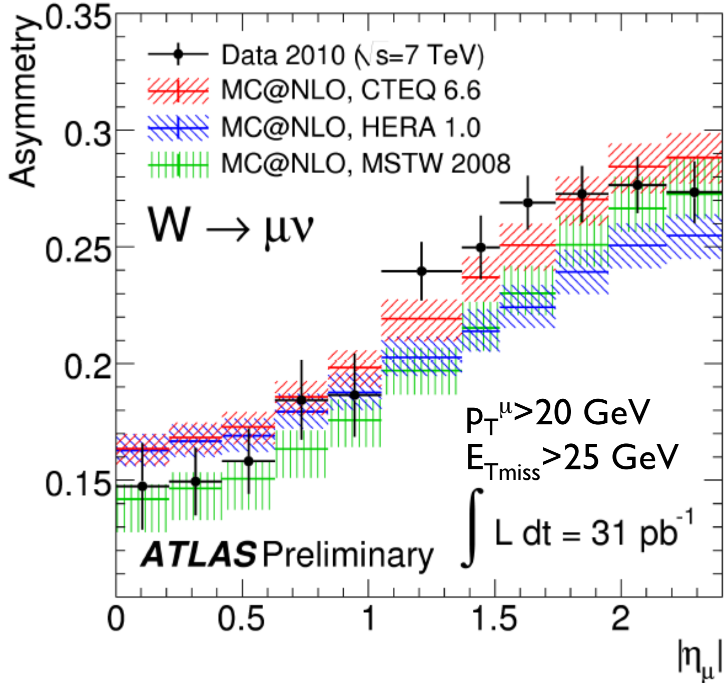
HERAPDF1.5 (NLO) vs Tevatron Data



- HERAPDF1.5 results in a reasonable agreement with the CDF data for the W asymmetry and the D0 lepton asymmetry, even if this data is not included in the HERA fits.

- DIS data from HERA predicts well Z and W at Tevatron from the ppbar processes.

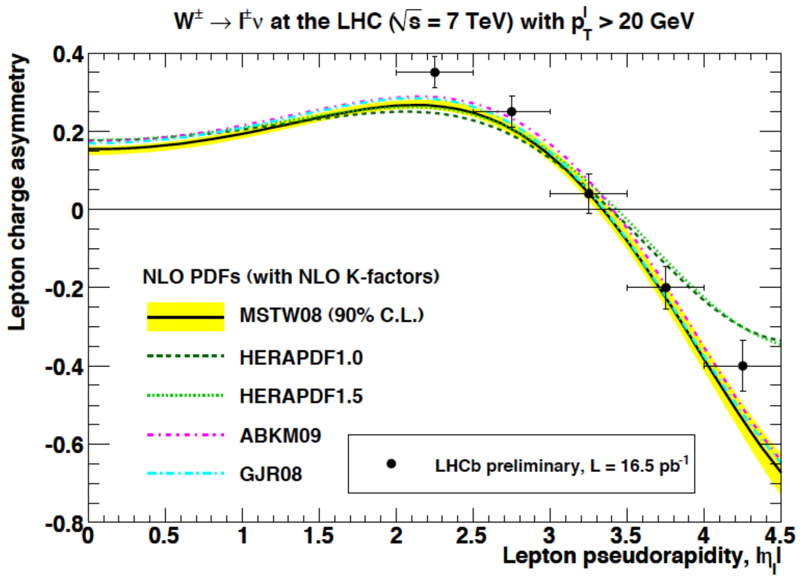
HERAPDF Predictions for W and lepton asymmetries at LHC

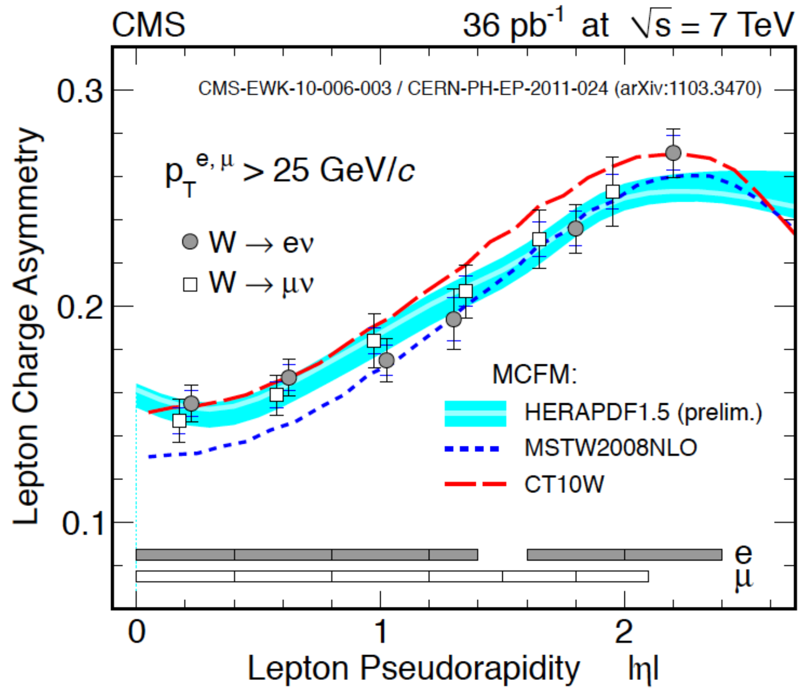


- W asymmetry is sensitive to differences between u and d
- Difference in u and d quarks can be better measured by all experiments at the LHC

$$A_{\pm}(y_W)=\frac{d\sigma/dy_W(W^+)-d\sigma/dy_W(W^-)}{d\sigma/dy_W(W^+)+d\sigma/dy_W(W^-)}$$

$$\approx\frac{u(x_1)\bar{d}(x_2)-d(x_1)\bar{u}(x_2)}{u(x_1)\bar{d}(x_2)+d(x_1)\bar{u}(x_2)}\approx\frac{u(x_1)-d(x_1)}{u(x_1)+d(x_1)}$$

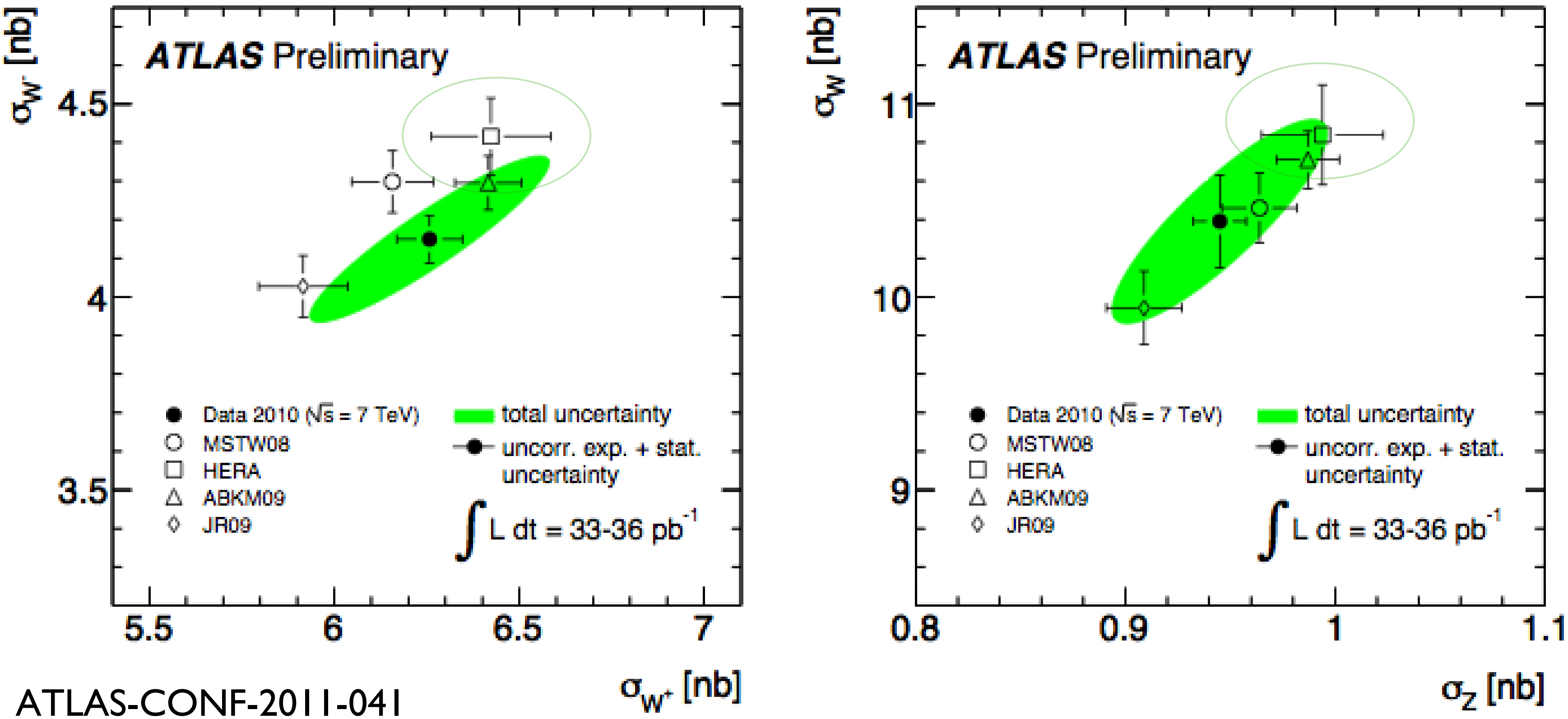




HERAPDF provides good description to pp process too

LHC predictions for W, Z cross sections

- Compare ATLAS measured and predicted cross sections (NNLO):
  - HERAPDF1.0(alphas=0.1145), ABKM, JR09, MSTW08

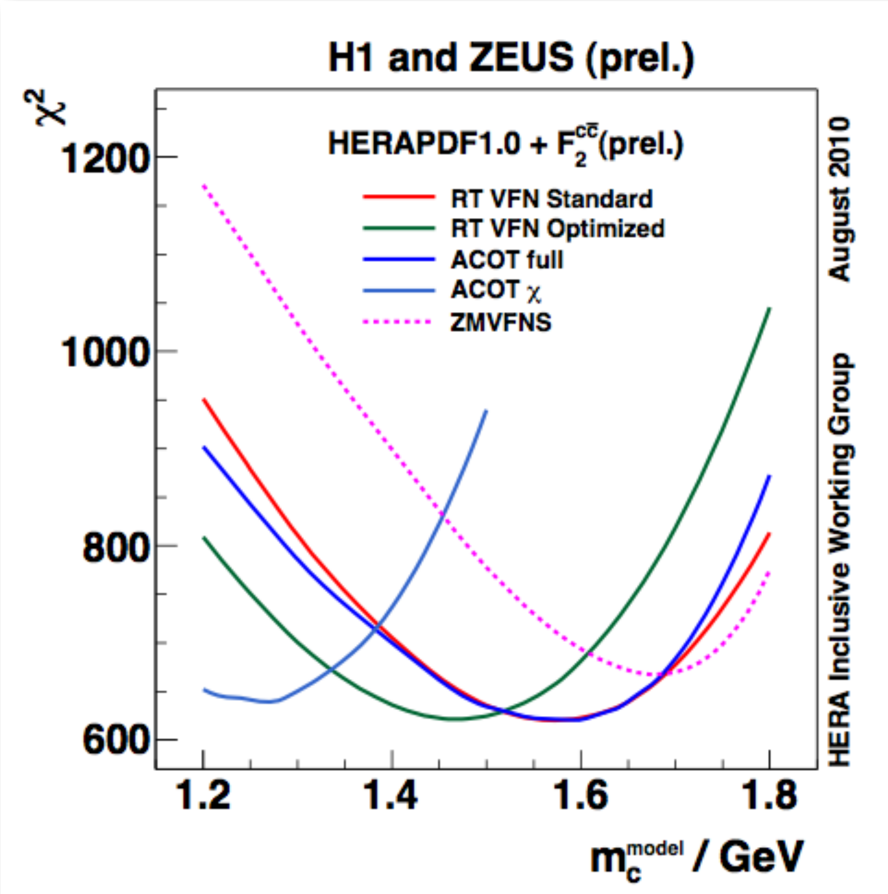


ATLAS-CONF-2011-041

HERAPDF1.0 based solely on ep data provides a competitive prediction to the LHC data!

Effects of inclusion of the HERA charm data

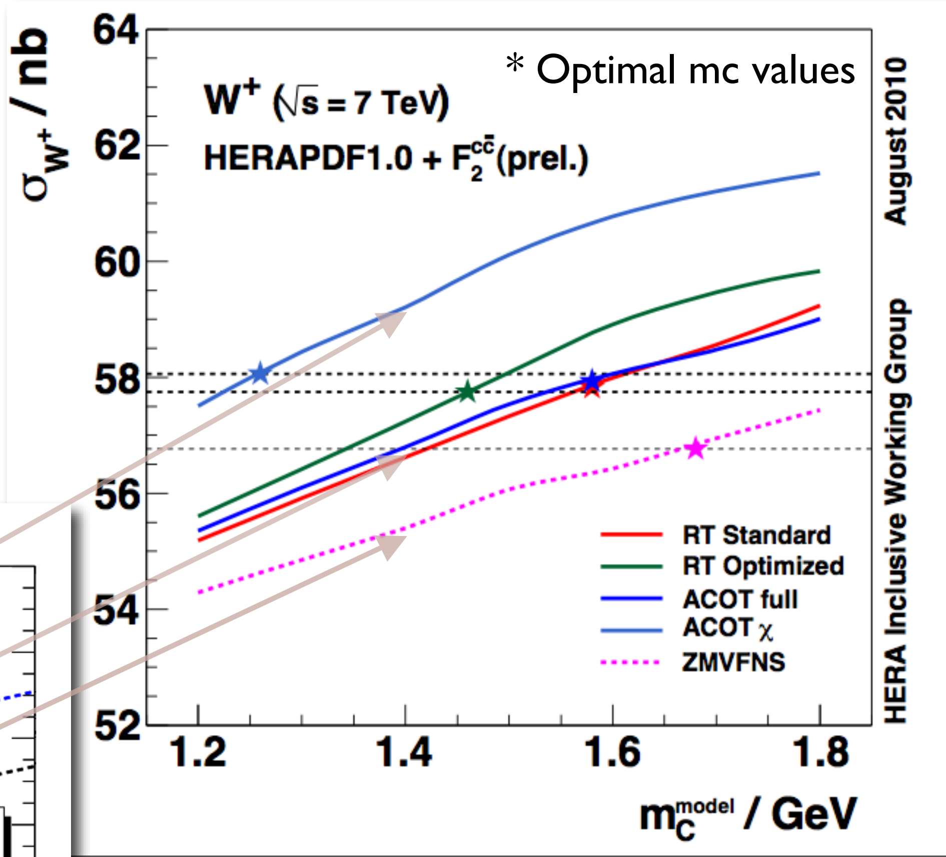
- QCD fits without charm data have only small sensitivity to the value of the charm mass
- However, there is a strong preference for a particular m_c once charm data is included
  - Study performed for RT, ACOT, ZMVFNS schemes

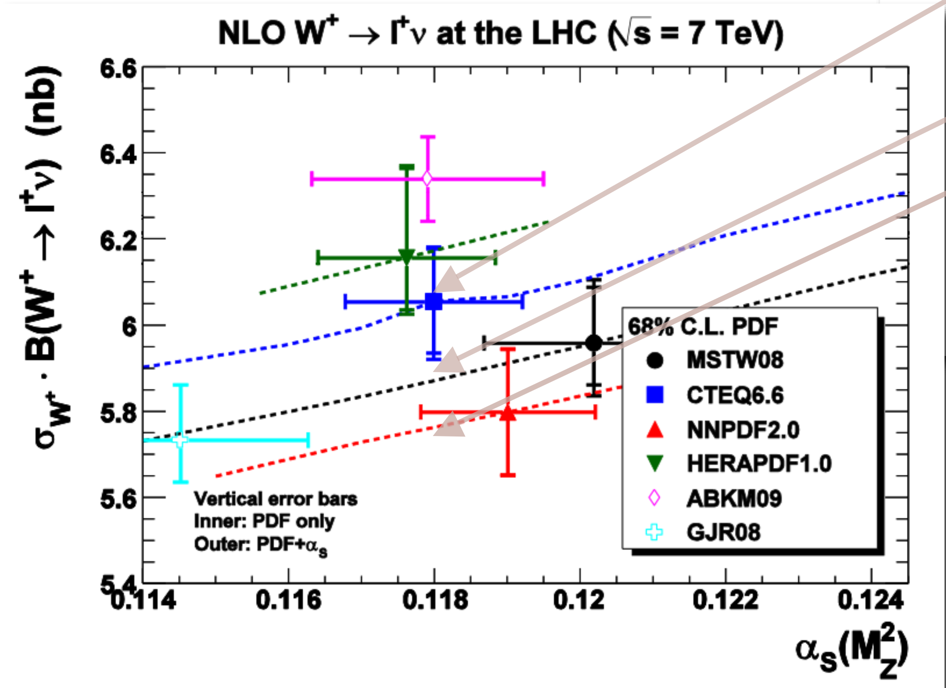


- Comparisons of the χ^2 minima of HERA I + charm data using different schemes that account for quark masses (shown in different colors)
- Observe sizeable spread in optimal values of mc: 1.25 - 1.68 GeV
  - RT Standard:
    - m_c=1.57 GeV
    [for MSTW08: 1.4 GeV]
  - RT Optimised:
    - m_c=1.47 GeV
  - ACOTχ
    - m_c=1.25 GeV
    [for CTEQ: 1.3 GeV]
  - ACOT full
    - m_c=1.58 GeV
  - ZMVFNS
    - m_c=1.68 GeV
    [for NNPDF: 1.4 GeV]
- Each scheme describes data well at the corresponding χ^2 minimum

Propagate PDFs to W LHC predictions

- Dependence of the W cross section prediction to the values of m_c [1.2-1.8 GeV] shown for different VFN schemes:
  - Sizeable spread is observed if looking at a fixed mc values between schemes (~4.5% (7% with ZMVFNS))
  - For each scheme the variation of the prediction varies by about 7%





- The spread is reduced if optimal value for mc is used, 0.7% (2.3% if ZMVFNS included)
- Interesting to observe that differences in the PDF sets correspond to differences in the charm mass used in different schemes.

Summary

- HERA provides unique determinations of the proton structure and can predict related Standard Model processes.
- New preliminary measurements are available in the HERA QCD analyses based on combined preliminary HERA I+II data [1fb^{-1}]:
  - High x region is better constraint resulting in more precise HERA PDF sets
    HERAPDF1.5 @ NLO and NNLO with full uncertainty band.
    - DIS scattering at HERA provides good description of Tevatron and LHC W, Z results
  - Inclusion of HERA DIS Jet data allows for a simultaneous constraint of the strong coupling and gluon and this results in a rather larger value of alphas.
  - Inclusion of the HERA Charm data provides constraints for the optimal value of the charm mass used in the theory models:
    - May account for some of the differences among global PDF fits.
- HERAPDF is a unique platform for understanding the q-g dynamics in the proton by focused studies based on new HERA measurements and for providing predictions as of Higgs production at the LHC, free of higher twist and nuclear corrections which are inherent to global fits.

https://www.desy.de/h1zeus/combined_results/index.php?do=proton_structure

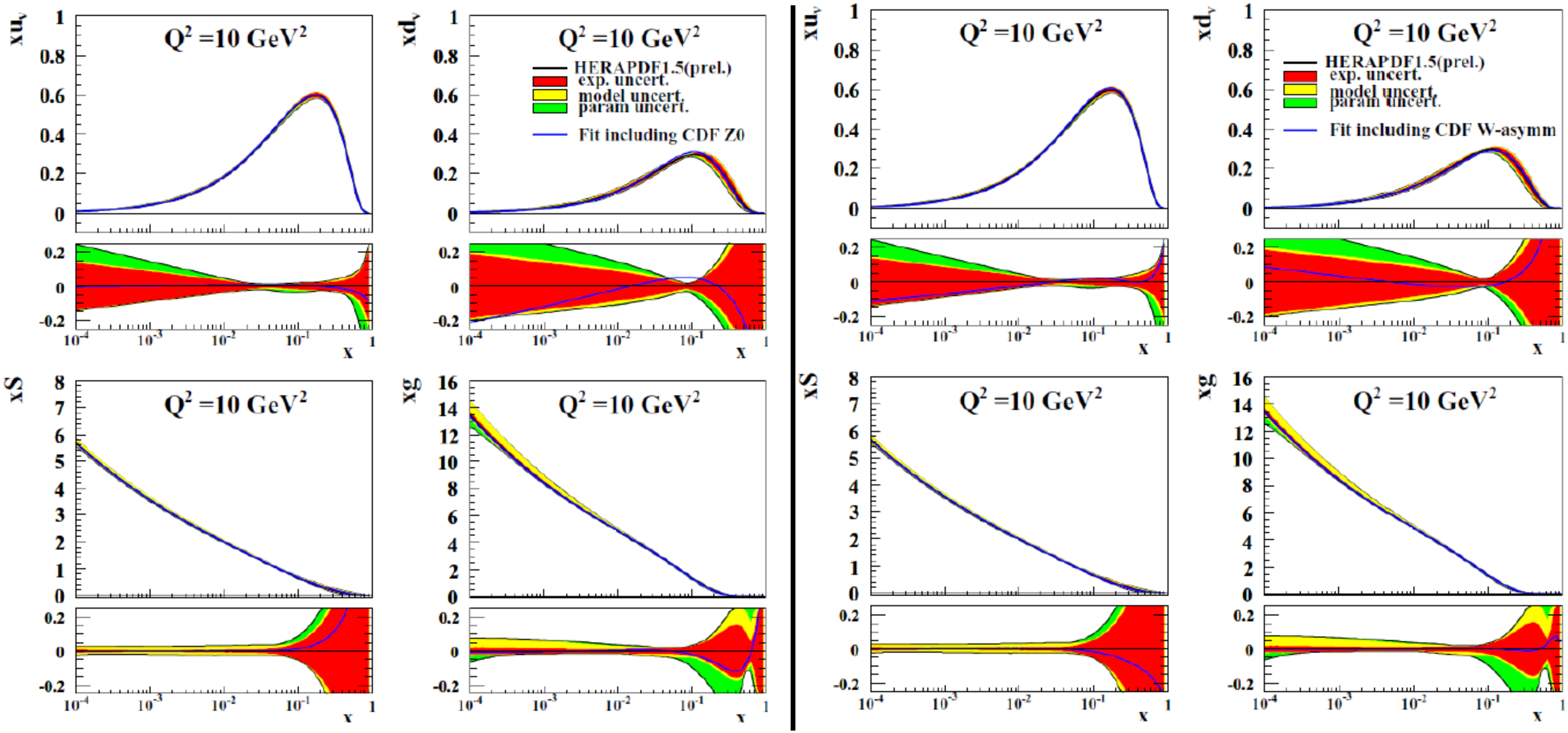
Rencontres de Moriond

Extra for Discussions

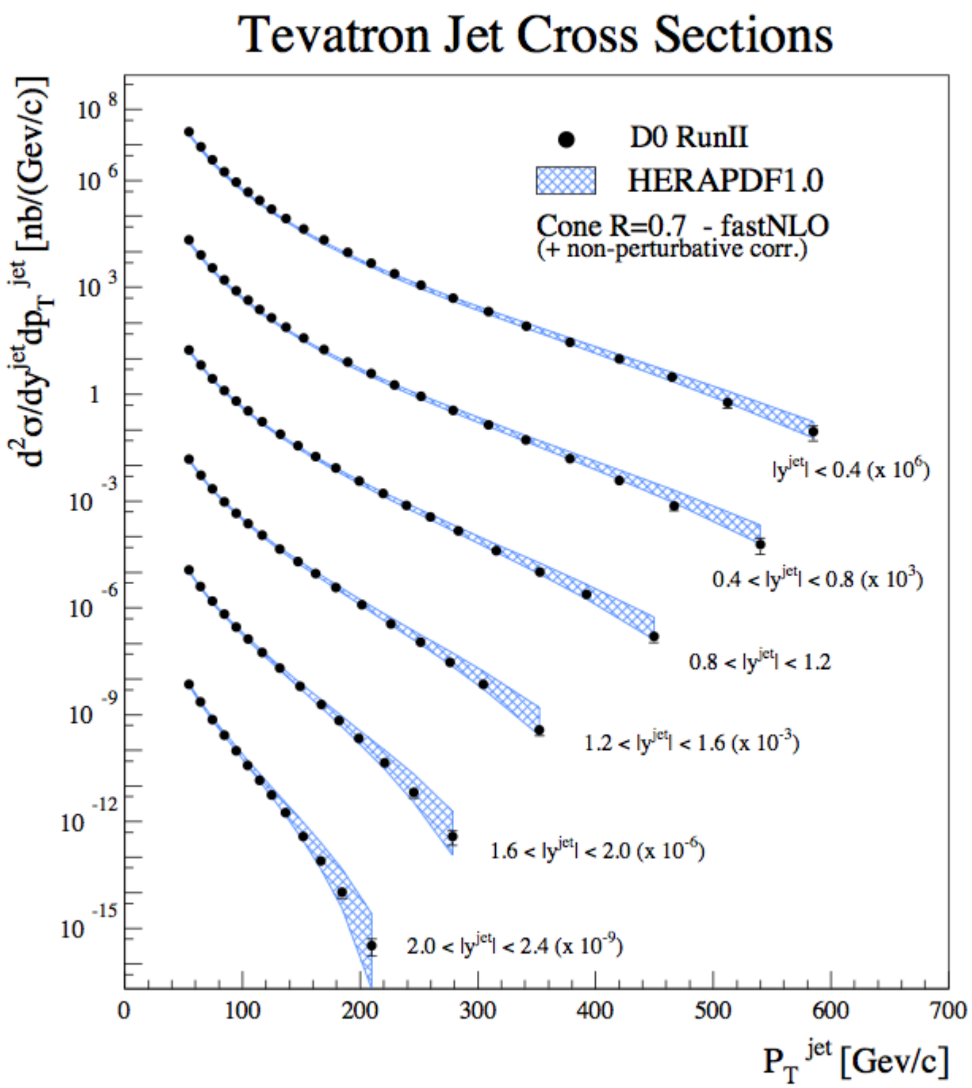
More into HERAPDF1.5 vs Tevatron

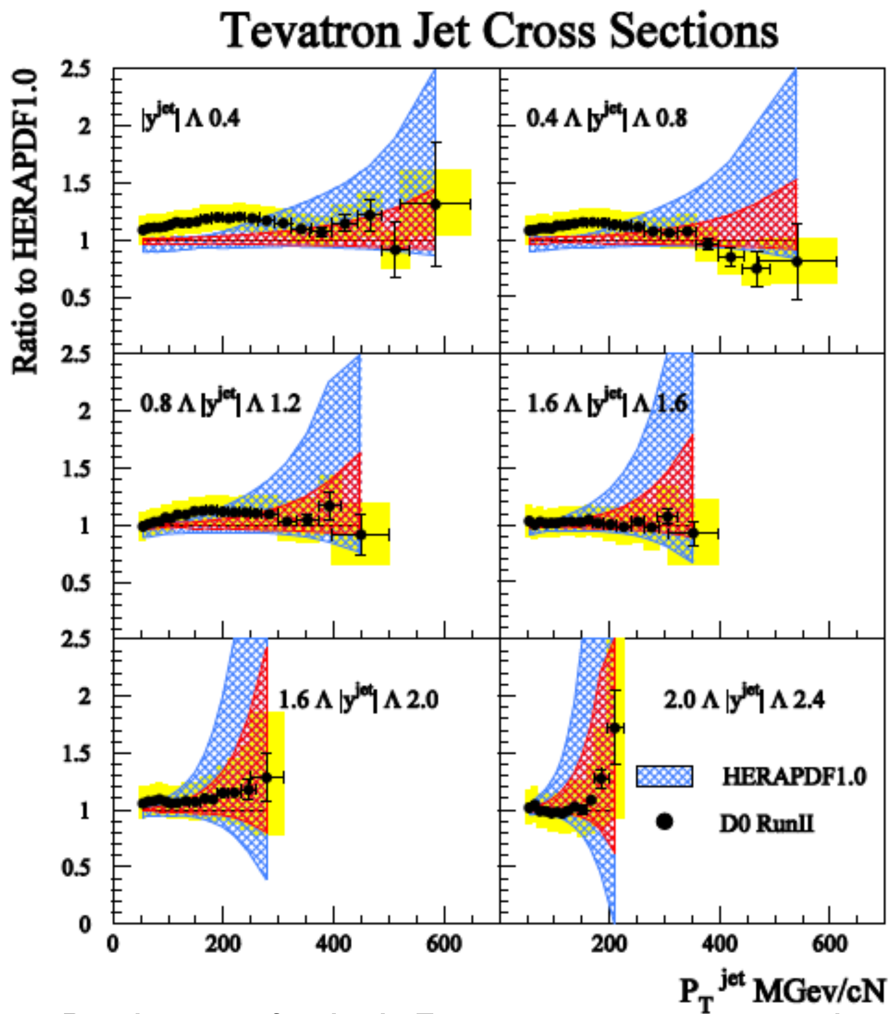
- Central line:
  - No fit : CDF Z rapidity: 36/28 CDF W asymmetry: 40/13
  - With fit: CDF Z rapidity: 31/28 CDF W asymmetry: 21/13

- However, the uncertainty on the prediction should be considered!



HERAPDF1.0 vs Tevatron Jet Data





- Predictions for high-E_T jet cross-sections with full uncertainties compared to the D0 data
- DIS data from HERA predicts Tevatron jets production from ppbar process.

More on Tevatron Jets

escription of CDF II inclusive jet (k_T) data [hep-ex/0701051]

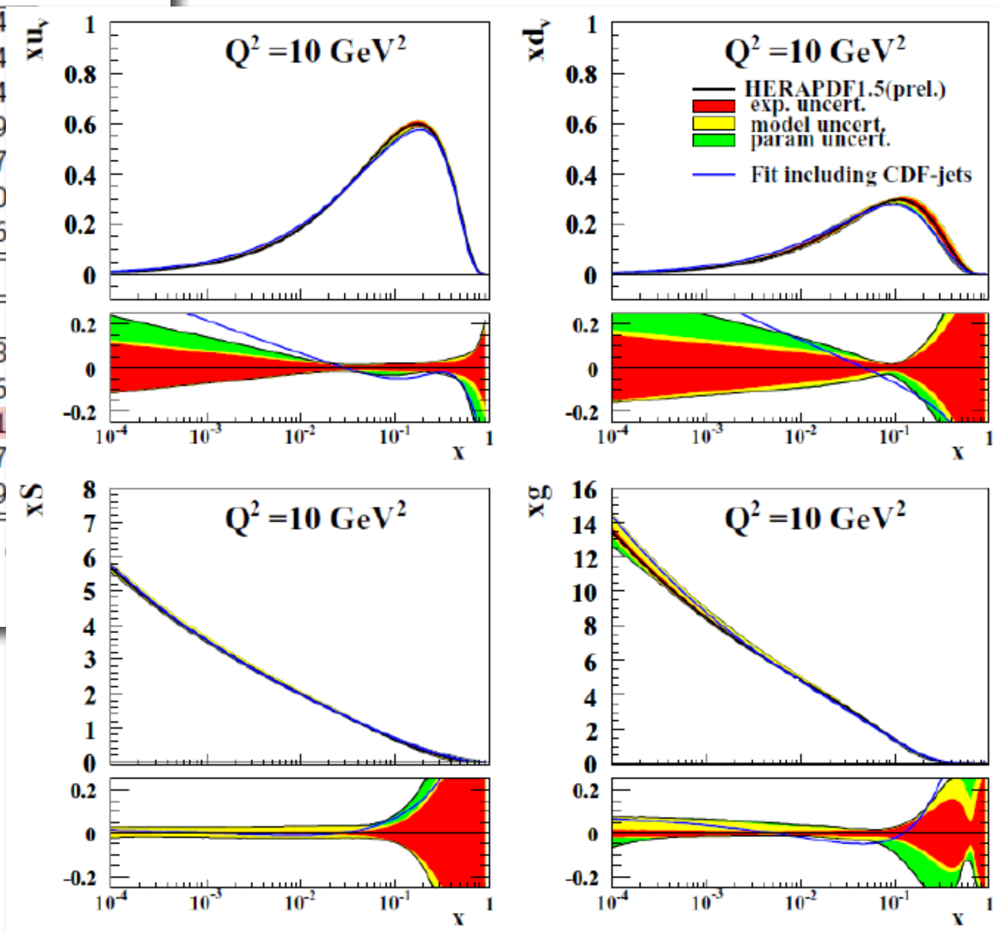
- Values of $\chi^2/N_{\text{pts.}}$ with (without) accounting for correlations:

NLO PDF	$\mu = p_T/2$	$\mu = p_T$	$\mu = 2p_T$
MSTW08	0.75 (0.30)	0.68 (0.28)	0.91 (0.84
CTEQ6.6	1.25 (0.14)	1.66 (0.20)	2.38 (0.84
CT10	1.03 (0.13)	1.20 (0.19)	1.81 (0.84
NNPDF2.1	0.74 (0.29)	0.82 (0.25)	1.23 (0.69
HERAPDF1.0 ($\alpha_S = 0.1176$)	2.43 (0.39)	3.26 (0.66)	4.03 (1.67
ABKM09	1.62 (0.52)	2.21 (0.85)	3.26 (2.10
GJR08	1.36 (0.23)	0.94 (0.13)	0.79 (0.36

NNLO PDF	$\mu = p_T/2$	$\mu = p_T$	$\mu = 2p_T$
MSTW08	1.39 (0.42)	0.69 (0.44)	0.97 (0.48
HERAPDF1.0 ($\alpha_S = 0.1145$)	2.64 (0.36)	2.15 (0.36)	2.20 (0.46
HERAPDF1.0 ($\alpha_S = 0.1176$)	2.24 (0.35)	1.17 (0.32)	1.23 (0.31
ABKM09	2.55 (0.82)	2.76 (0.89)	3.41 (1.17
JR09	0.75 (0.37)	1.26 (0.41)	2.21 (0.49

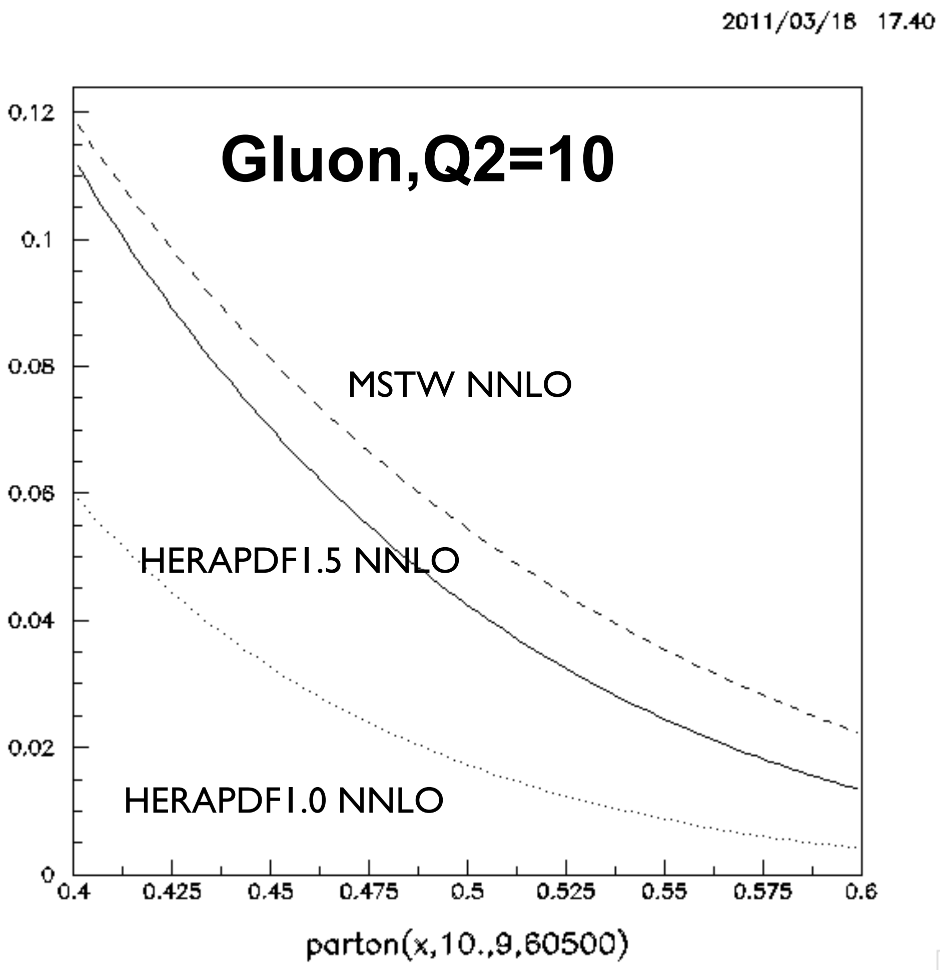
- Similar trends for CDF II (cone) data and DØ II (cone)

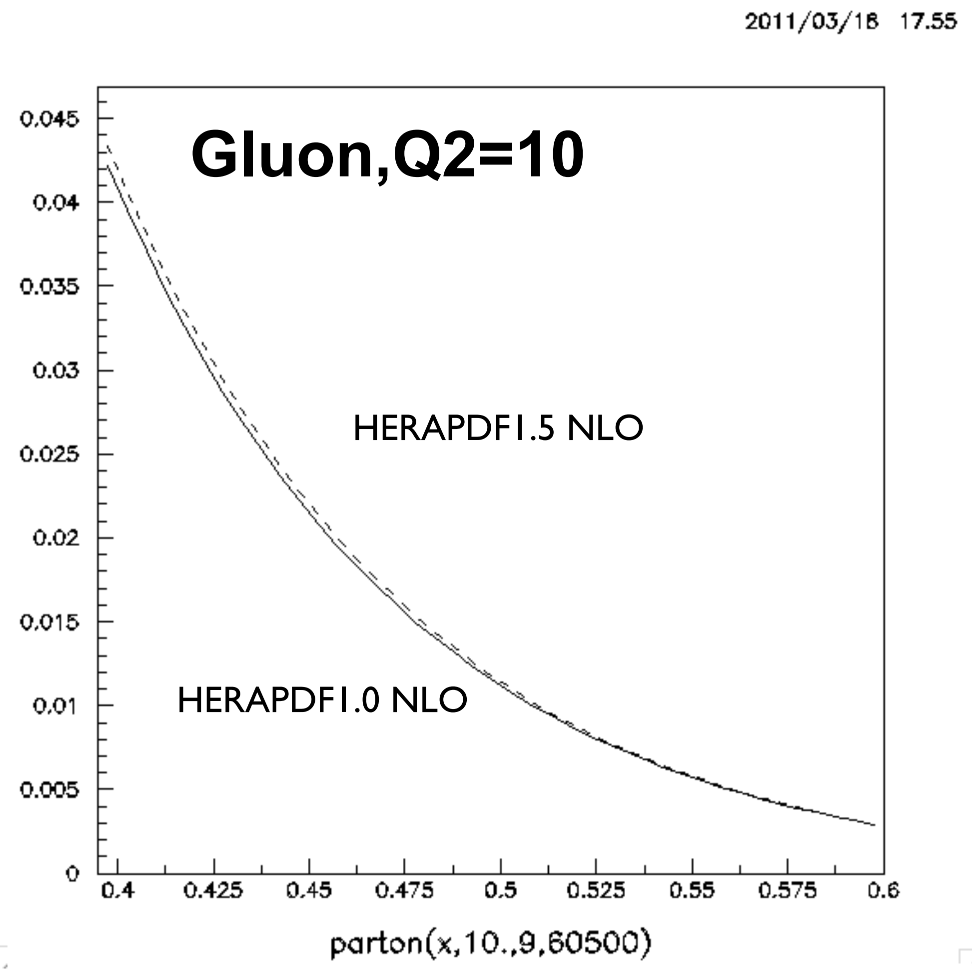
Table from G Watt



- Based on HERAPDF1.5 (NLO):
  - NO fit : 176/76 (central line)
    - Similar to HERAPDF1.0 due to the same high x gluon between 1.0 and 1.5
  - After fit: 113/76
- HERAPDF1.5 NLO describes Tevatron Data within uncertainties!
- HERAPDF1.5 NNLO: NO fit: 84/76

comparisons

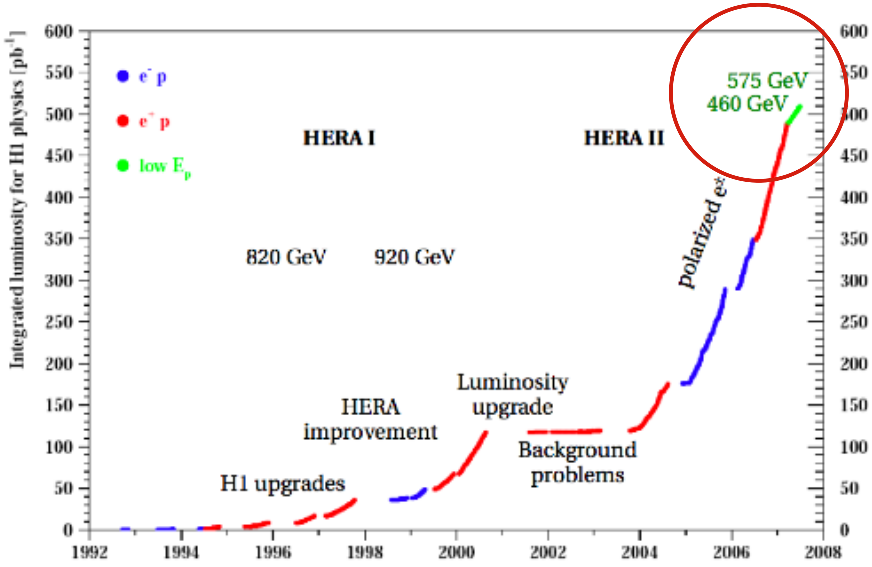




Rencontres de Moriond

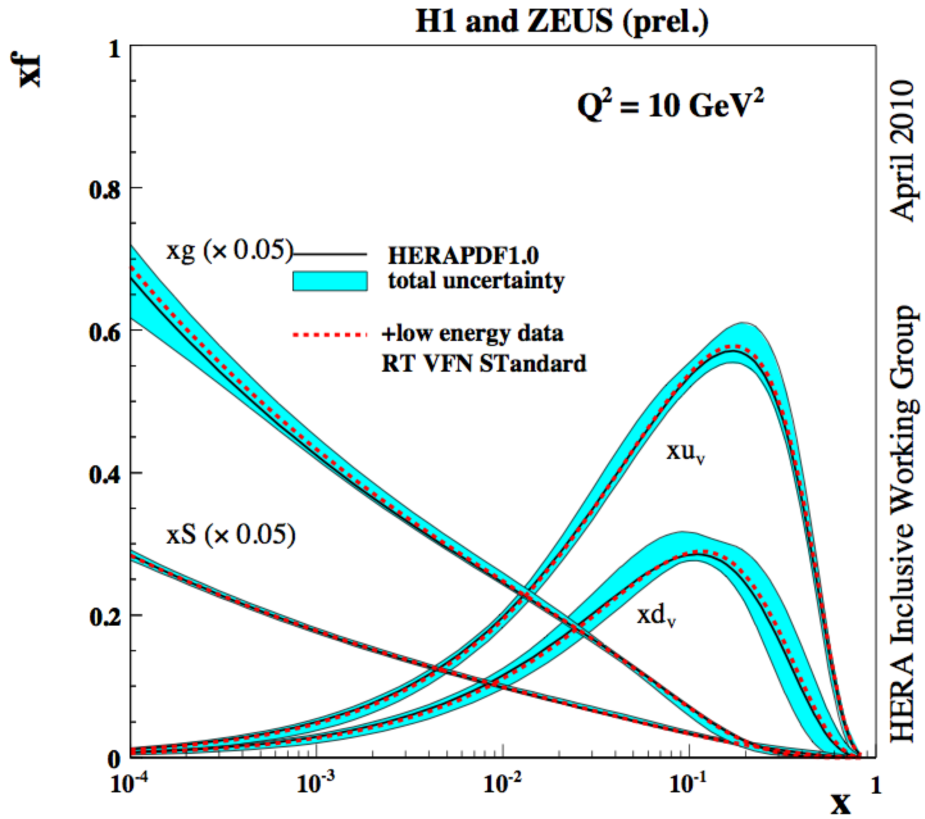
Other issues …

HERAPDF including Low Energy data



- Preliminary HERA Combined Low Energy data available!

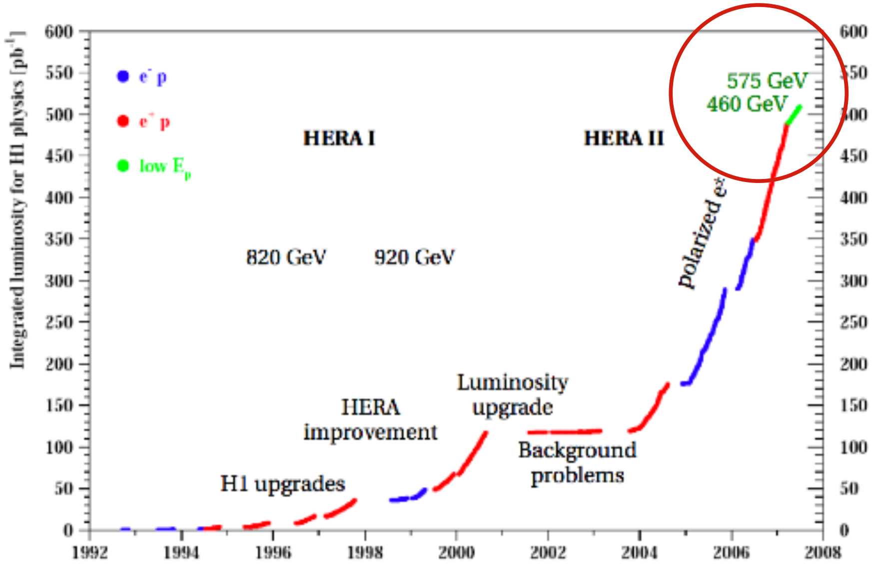
- New accurate measurement in $Q^2>2.5\ GeV^2$ range, sensitive to structure function F_L are included in the QCD analysis on top of the HERA I data➔



- PDFs from the new fit agree very well with HERAPDF1.0

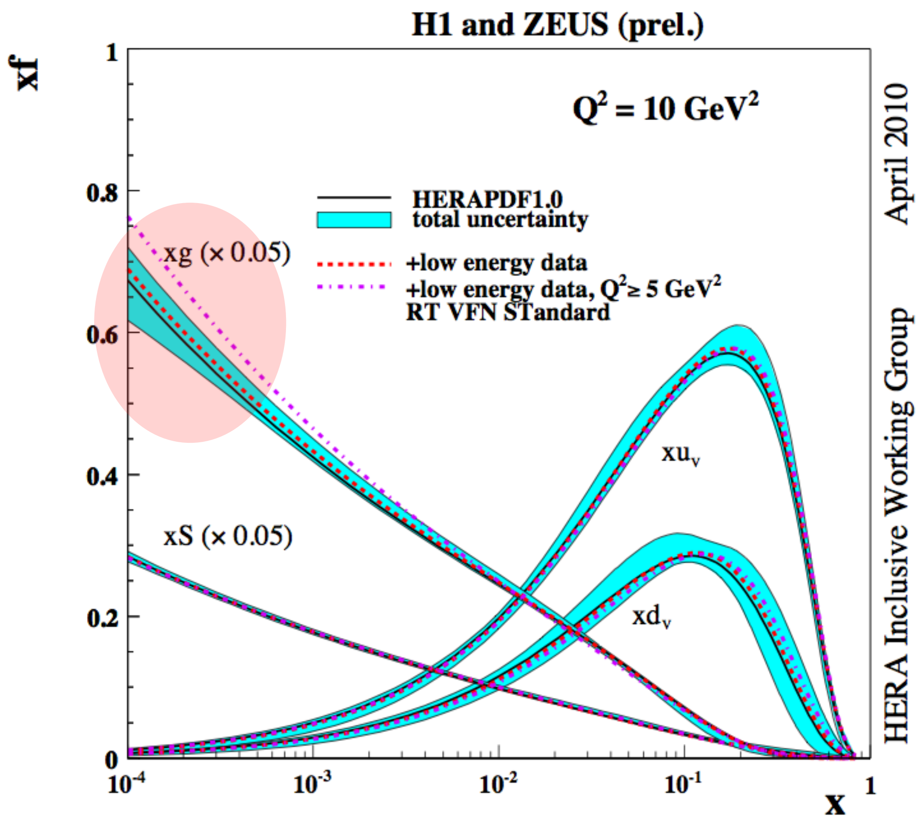
Data sets	HERAPDF1.0	+ Low Energy data
Total χ^2/dof	574/582	818/806

HERAPDF including Low Energy data



- Preliminary HERA Combined Low Energy data available!

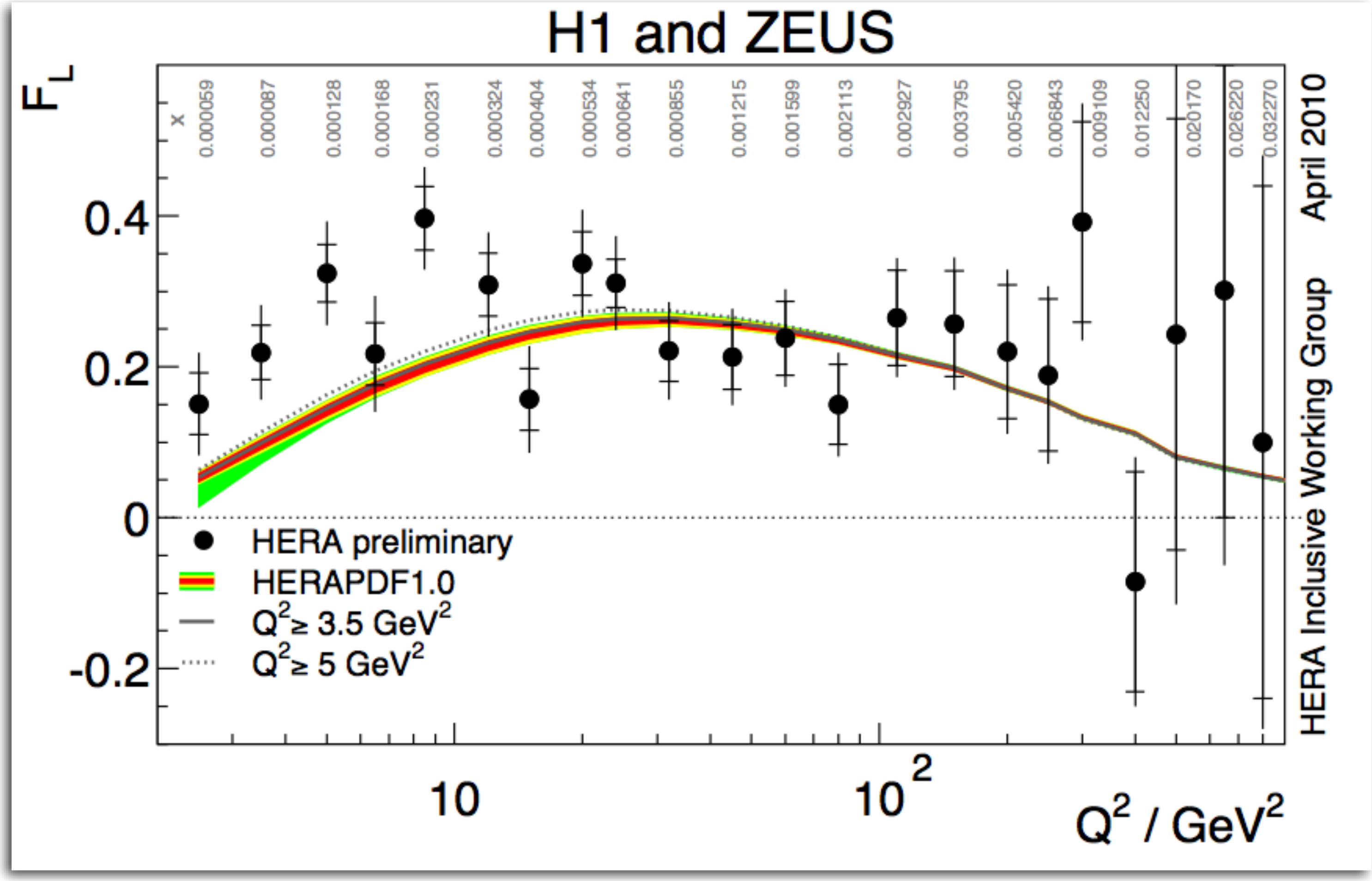
- New accurate measurement in Q^2>2.5 GeV^2 range, sensitive to structure function F_L are included in the QCD analysis on top of the HERA I data➔



- However, The Q^2 ≥5 GeV^2 cut brings large improvement in χ^2 [818/806 → 698/771] and it yields different shapes for gluon and sea PDFs.
  - for HERAPDF1.0, Q^2 cut variation is included in the model uncertainty, but it had smaller effect.

HERA F_L data vs F_L predictions

The lines are F_L predictions using combined HERA I and low energy data.

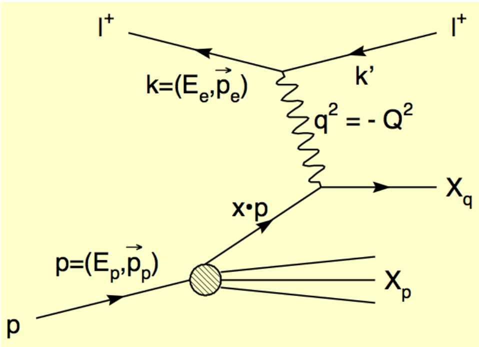


Low Q^2 region remains very interesting for further QCD tests!

Other issues …

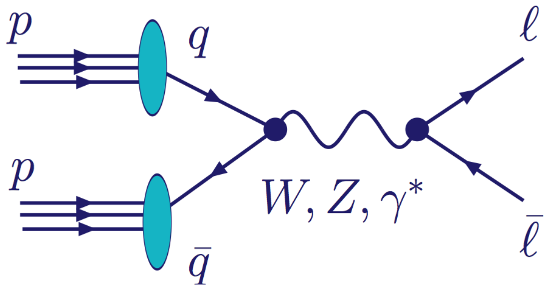
Probing the Proton Structure

- Deep Inelastic Scattering (DIS)



- Kinematic Variables
  - Virtuality of exchanged boson
    $Q^2 = -q^2 = -(k - k')^2$
  - Proton momentum fraction of the scattered quark (Bjorken variable)
    $$x = \frac{Q^2}{2p \cdot q}$$
  - Inelasticity parameter
    $$y = \frac{p \cdot q}{p \cdot k}$$
  - Invariant centre of mass energy
    $$s = (k + p)^2 = \frac{Q^2}{xy}$$

- Drell Yann (DY)

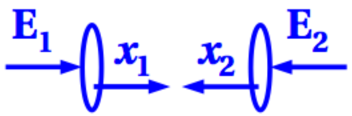


- Kinematic Variables
  - $Q^2 = M^2_{Z,W}$
  - rapidity y
    $$\text{rapidity } y = \frac{1}{2} \ln \frac{E + P_Z}{E - P_Z}$$
    $$x_1 = \frac{M}{\sqrt{s}} e^{y}; x_2 = \frac{M}{\sqrt{s}} e^{-y}$$
  - $s = 4E_p^{\ 2}$

Probing the Proton Structure

- At the LHC: Drell Yan (DY)

Proton-proton collisions:



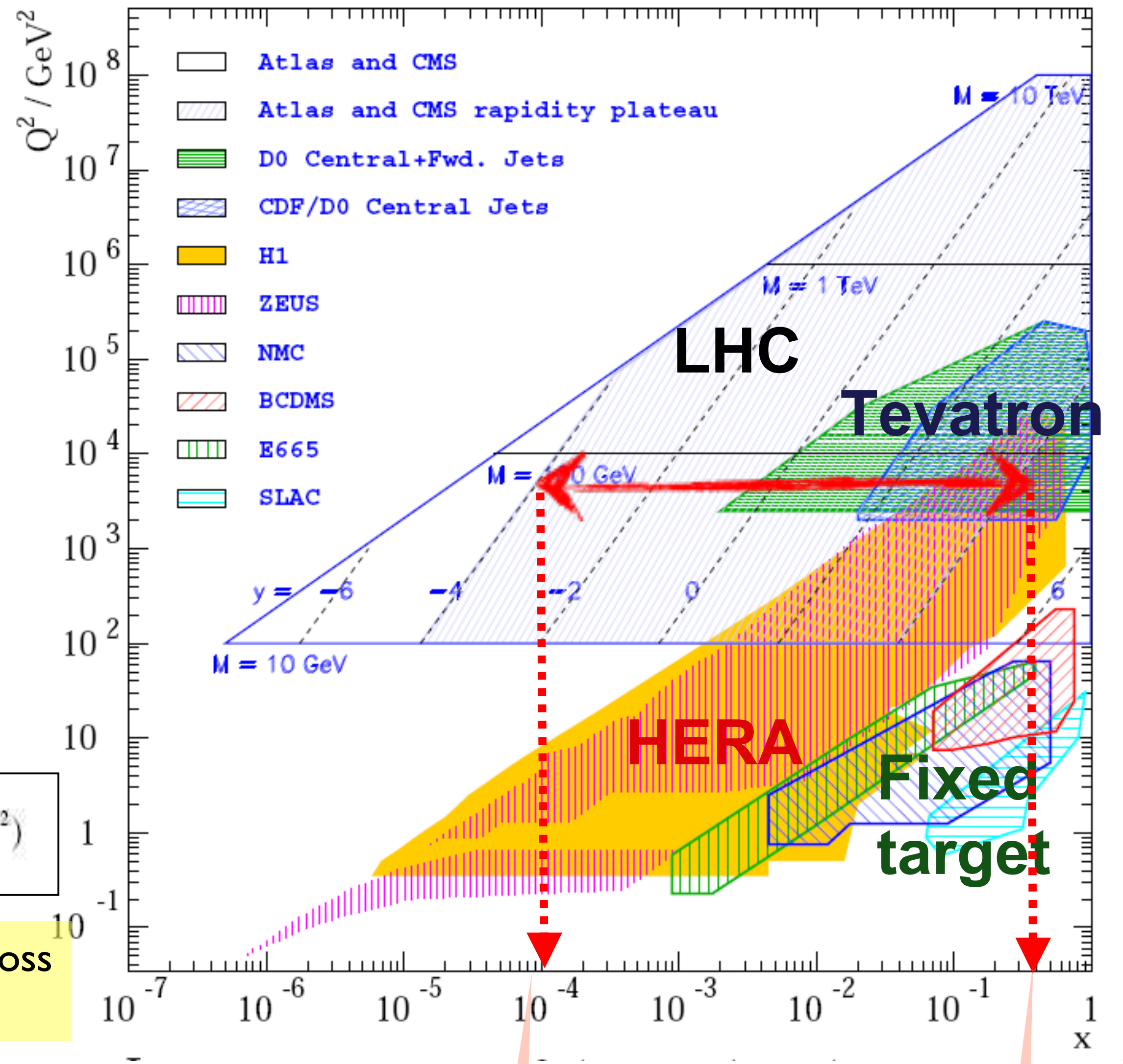
$$\text{rapidity } y = \frac{1}{2}\ln\frac{E + P_Z}{E - P_Z};$$

$$x_1 = \frac{M}{\sqrt{s}}e^{y};\, x_2 = \frac{M}{\sqrt{s}}e^{-y};$$

$$\sigma_X(Q^2) = \sum_{a,b}\int_0^1 dx_1 dx_2 f_a(x_1, Q^2) f_2(x_2, Q^2)\hat{\sigma}_{ab\to X}(x_1, x_2, Q^2)$$

hadronic cross section

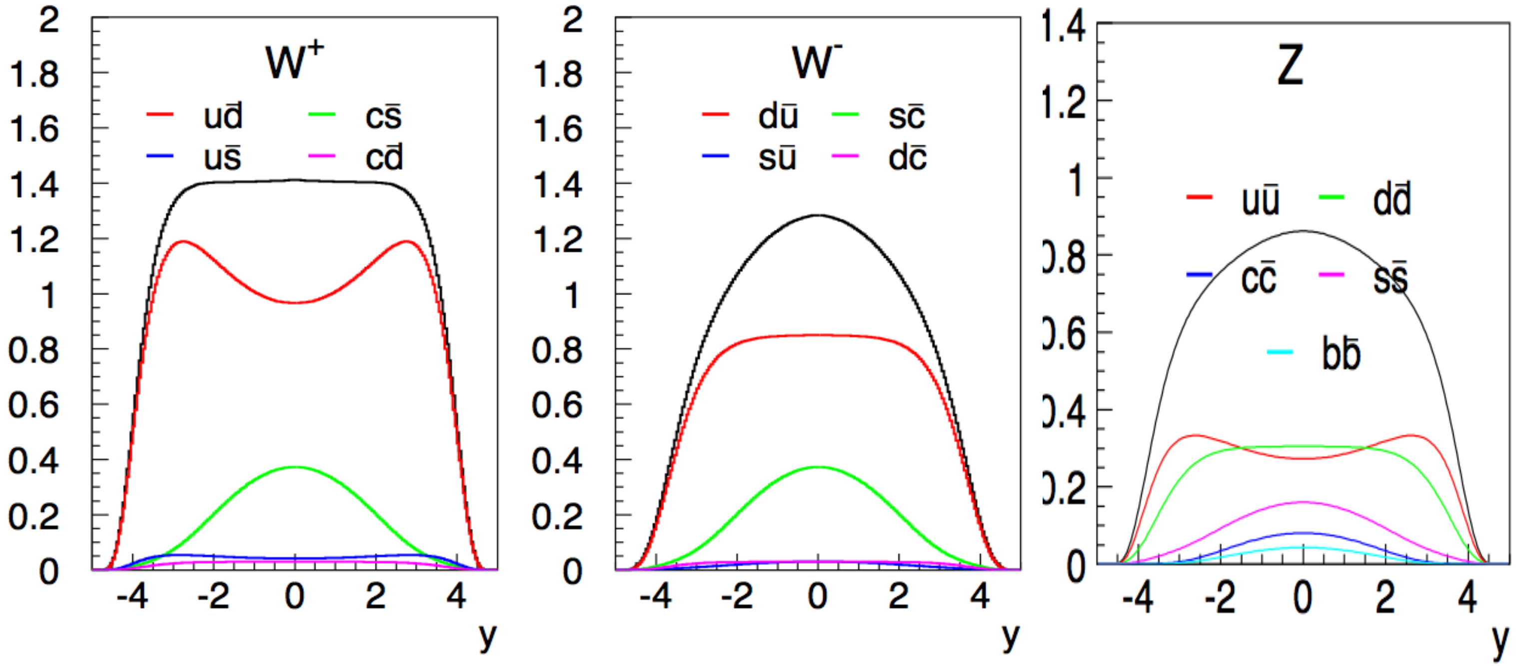
Partonic cross section

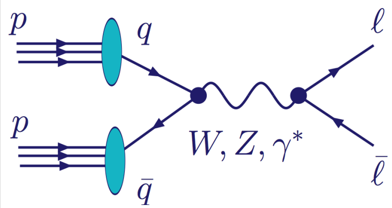


So, to predict Z or W production at LHC with a rapidity y=-4, it is needed:

$q(x_1=10^{-4}, Q^2=M^2_{W,Z})$ $q(x_1=0.3, Q^2=M^2_{W,Z})$

Decomposition of W and Z at the LHC





<u>Flavour decomposition:</u>

For Ws:

- ud dominates for W
- u_{val} peaks at large rapidity
- sc important at mid y

$$W^+ \sim 0.95(u\bar{d} + c\bar{s}) + 0.05(u\bar{s} + c\bar{d})$$
$$W^- \sim 0.95(d\bar{u} + s\bar{c}) + 0.05(d\bar{c} + s\bar{u})$$

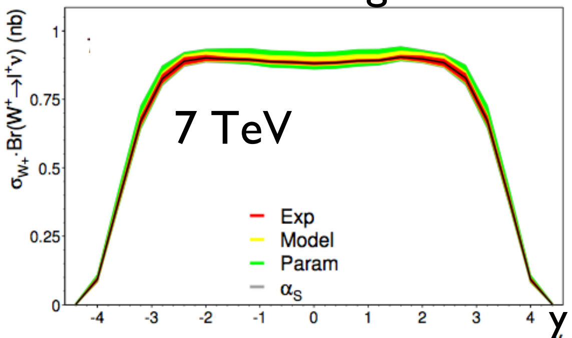
For Z:

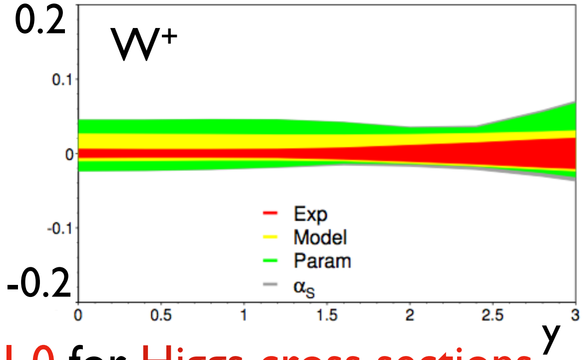
$$Z \sim 0.29(u\bar{u} + c\bar{c}) + 0.37(d\bar{d} + s\bar{s} + b\bar{b})$$
$$\gamma^* \sim 0.44(u\bar{u} + c\bar{c}) + 0.11(d\bar{d} + s\bar{s} + b\bar{b})$$

- all flavours contribute, even b is significant
- larger coupling to d compared to u

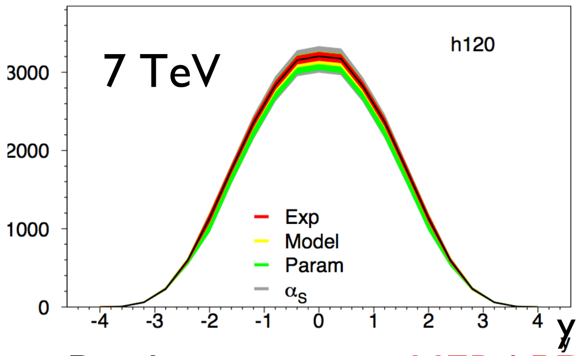
LHC predictions based on HERAPDF1.0

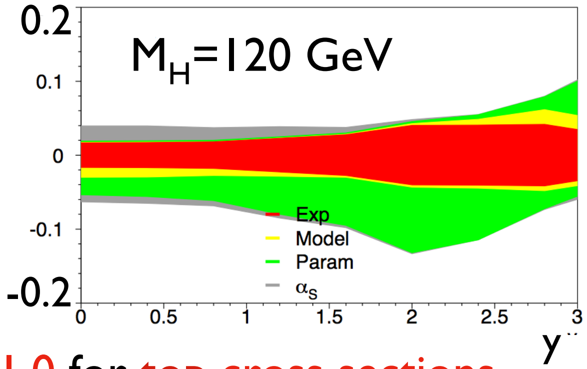
- Predictions using HERAPDF1.0 for W cross sections.



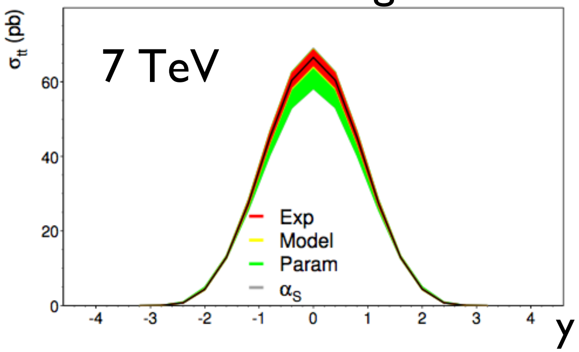


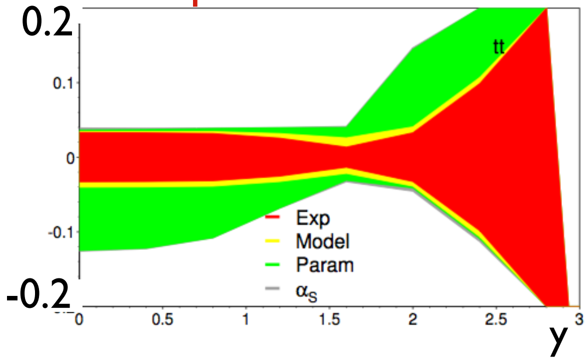
- Predictions using HERAPDF1.0 for Higgs cross sections.





- Predictions using HERAPDF1.0 for top cross sections.



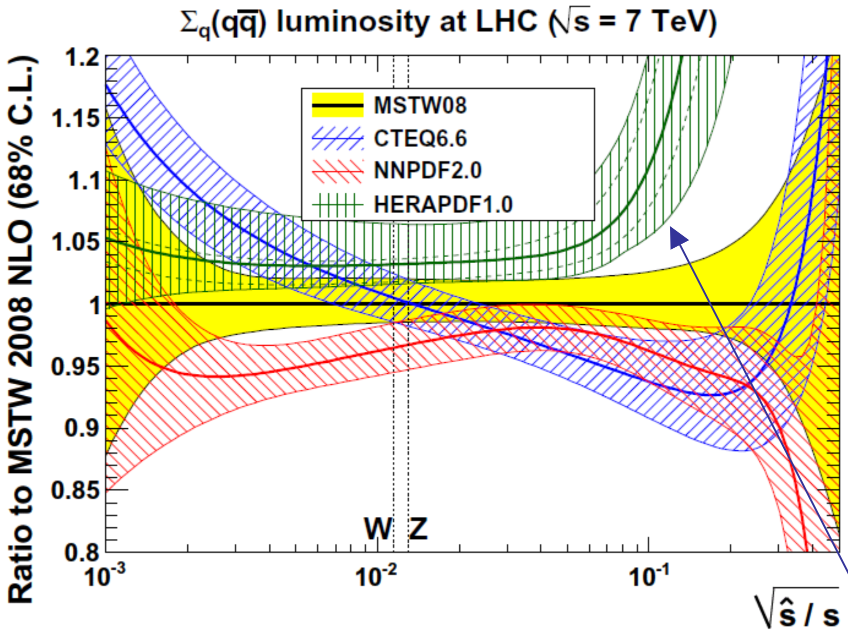


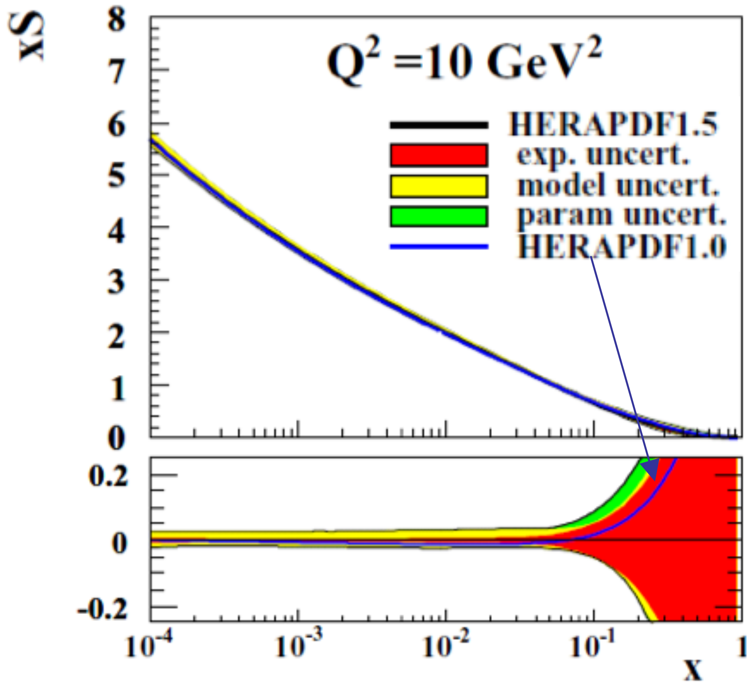
Uncertainties:

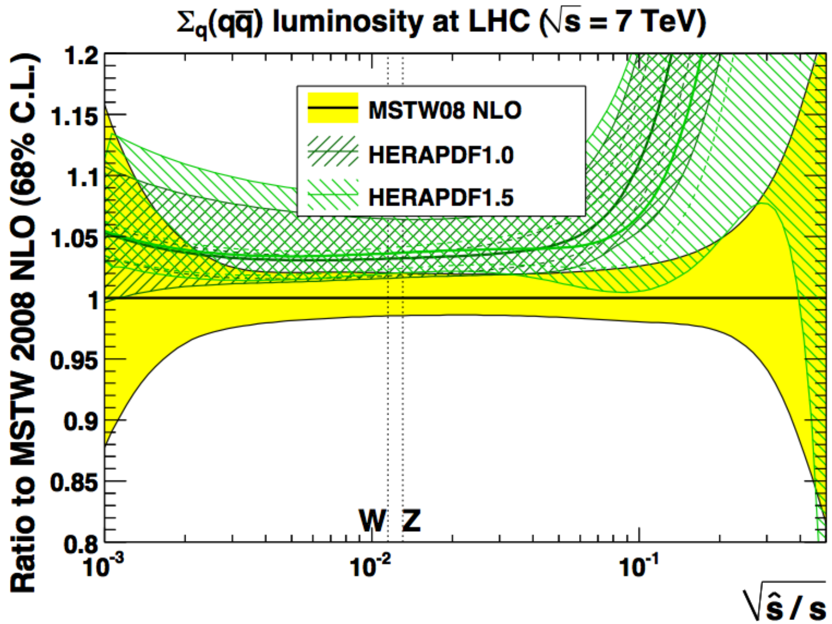
- Experimental
- Model
- Parametrisation
- α_S variation

Exciting new times ahead to actually compare the predictions to real measurements from the LHC!

Impact on the LHC predictions







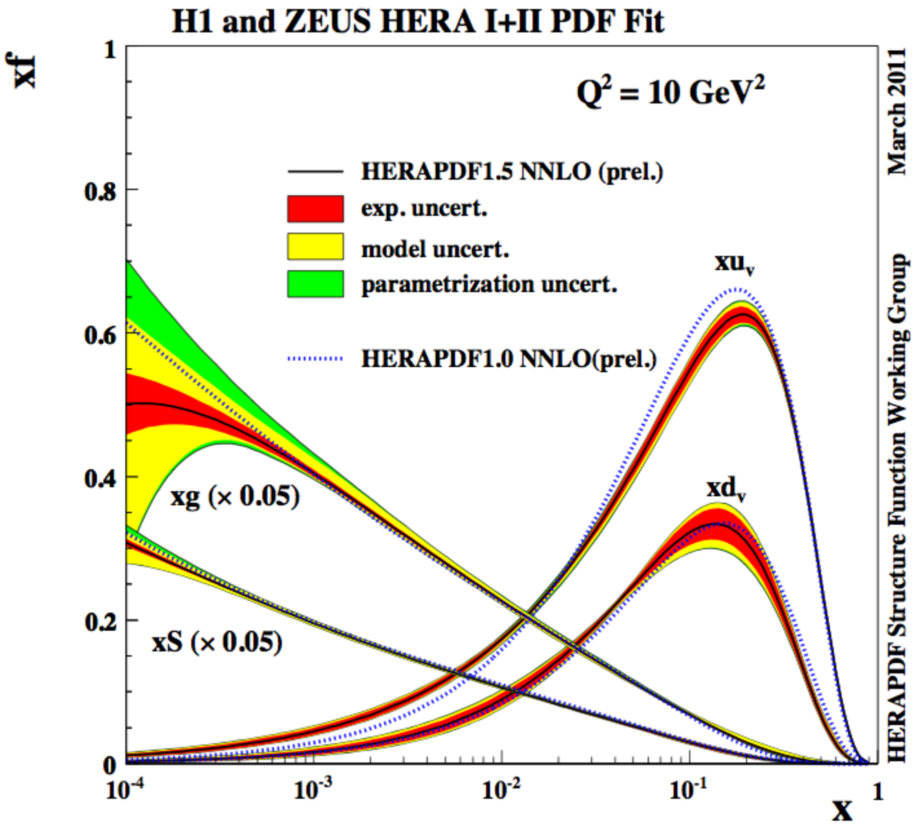
- HERAPDF1.0 is high at the large scale because Sea is hard at high x
- HERAPDF1.5 has a softer Sea, hence in a better agreement with other PDF sets

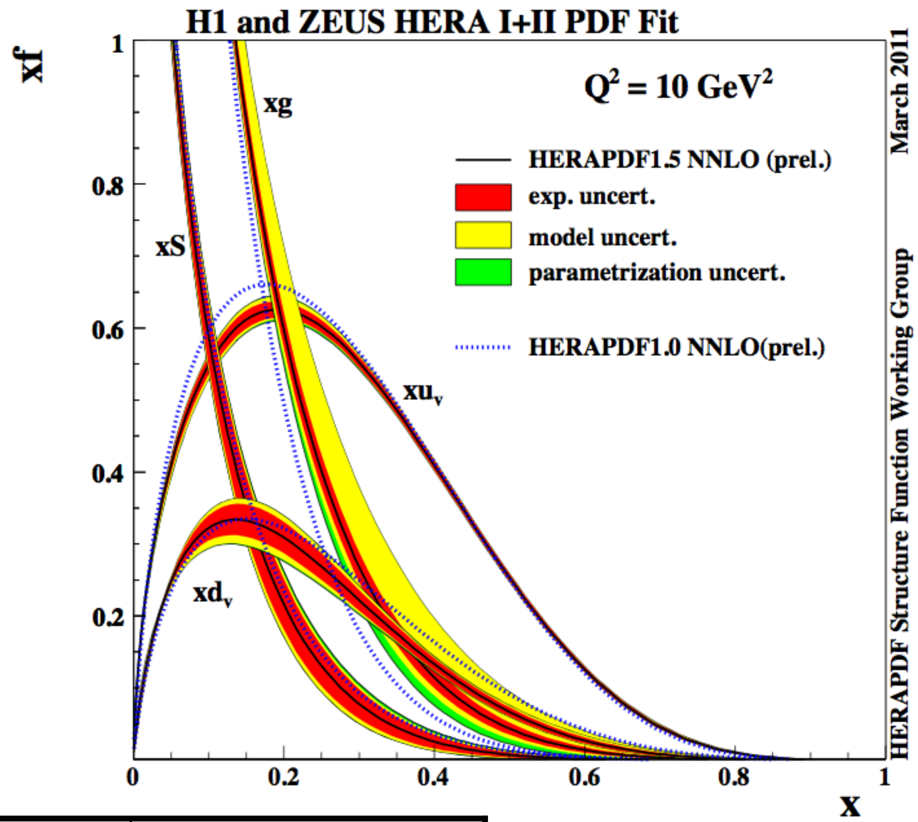
(plots courtesy of G.Watt)

Premiere!

Results based on HERA I+II data: HERAPDF1.5 (NNLO)

- Fits performed to HERA I data (as used for HERAPDF1.0) at NNLO using RT-VFNS:
  - α_S(Mz) at NNLO = 0.1176





scheme	NNLO α_S(Mz)=0.1176	NLO α_S(Mz)=0.1176
All χ^2/dof	744.3/660	735.1/660

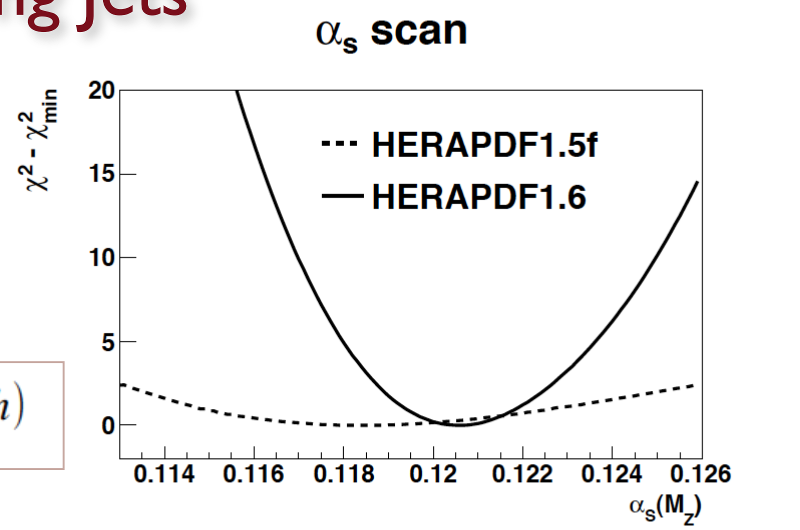
- HERAPDF1.5 NLO vs NNLO in much better agreement than for HERAPDF1.0 due to use of a more flexible parametrisation for the central fit (10p vs 14p fit)

Other issues …

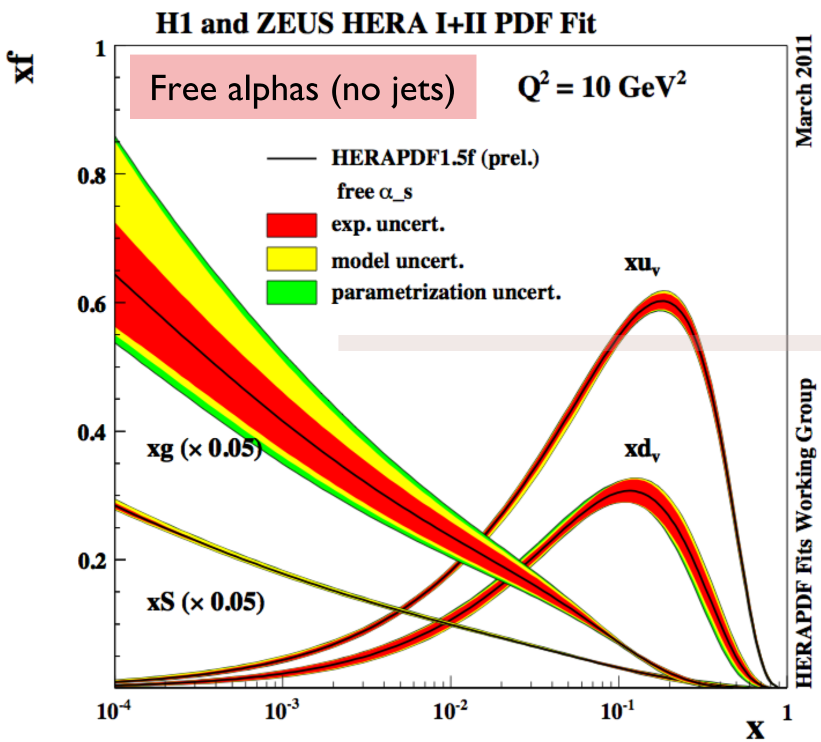
HERAPDF Fits including Jets

- Addition of the HERA Jet cross section data (NLOJet++) into the fits allows to constrain simultaneously alphas and gluon:
  - Due to strong correlation between alphas and gluon, a more flexible parametrisation is used by adding extra terms for gluon and valence (14 parameters)

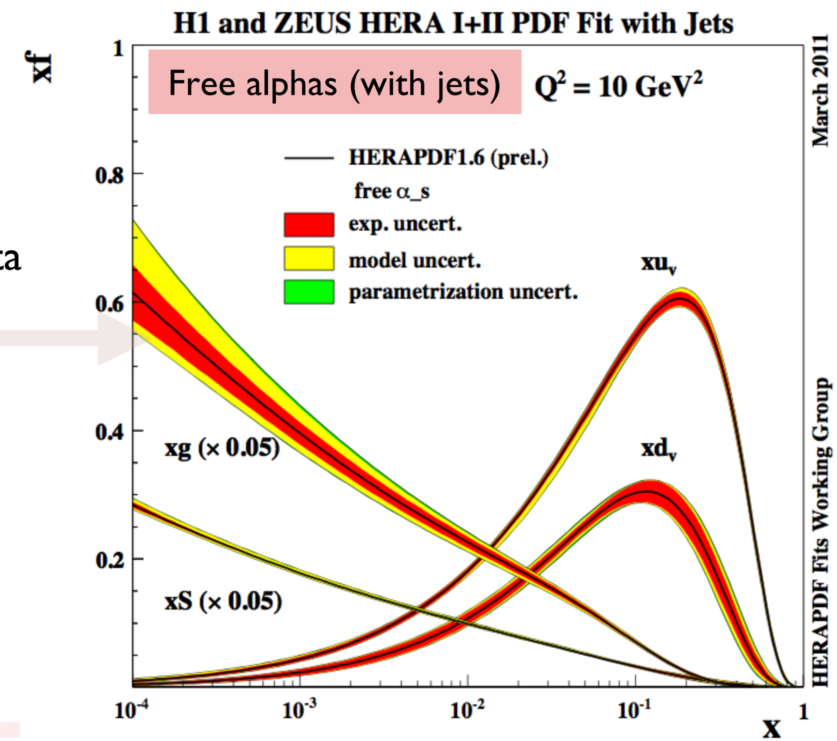
$$\alpha_s = 0.1202 \pm 0.0013\,(\exp) \pm 0.0007\,(mod) \pm 0.0012\,(had)^{+0.0045}_{-0.0036}\,(th)$$



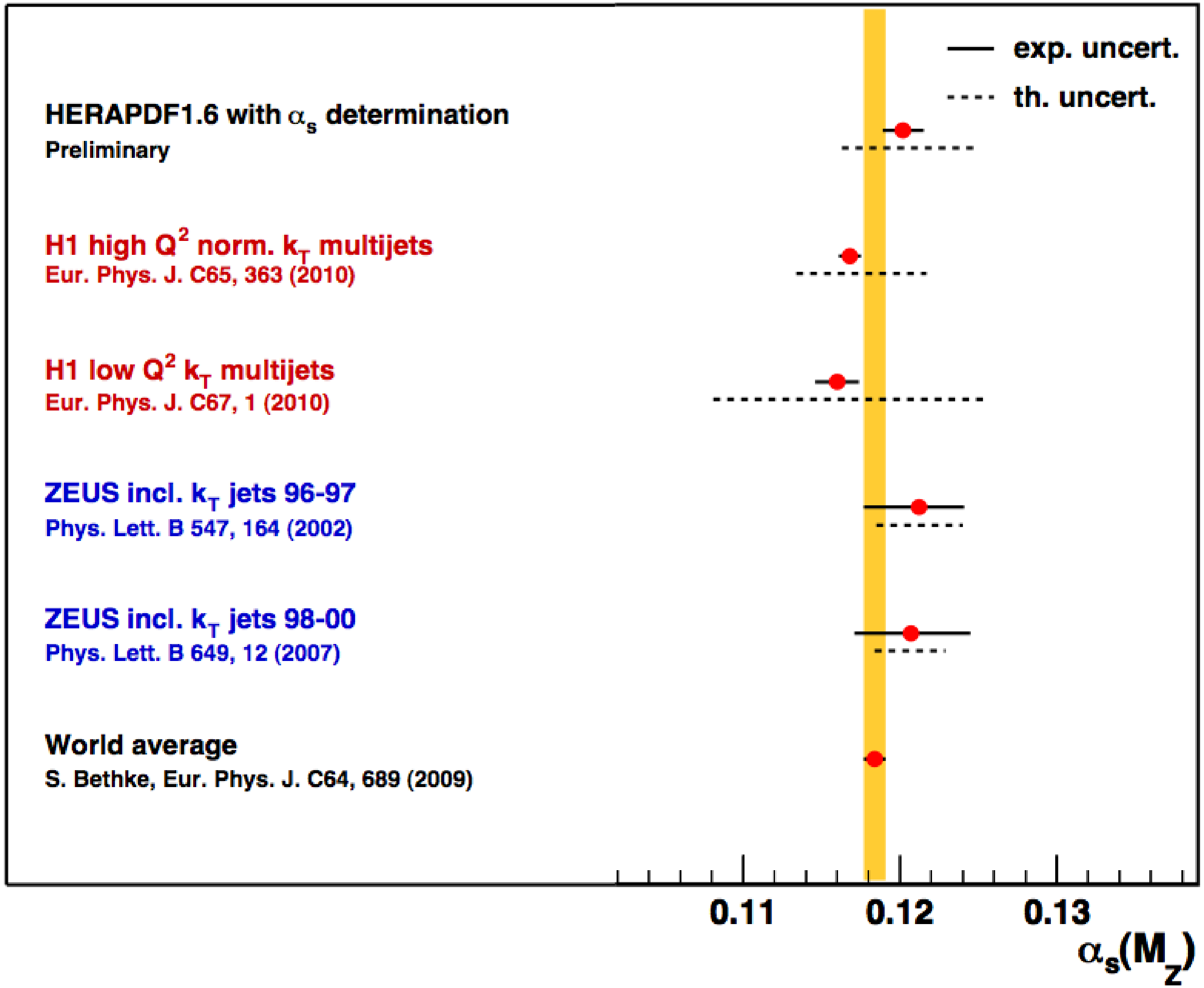
- HERA data prefer larger value for strong coupling.



Adding jet data



HERAPDF with Jet data



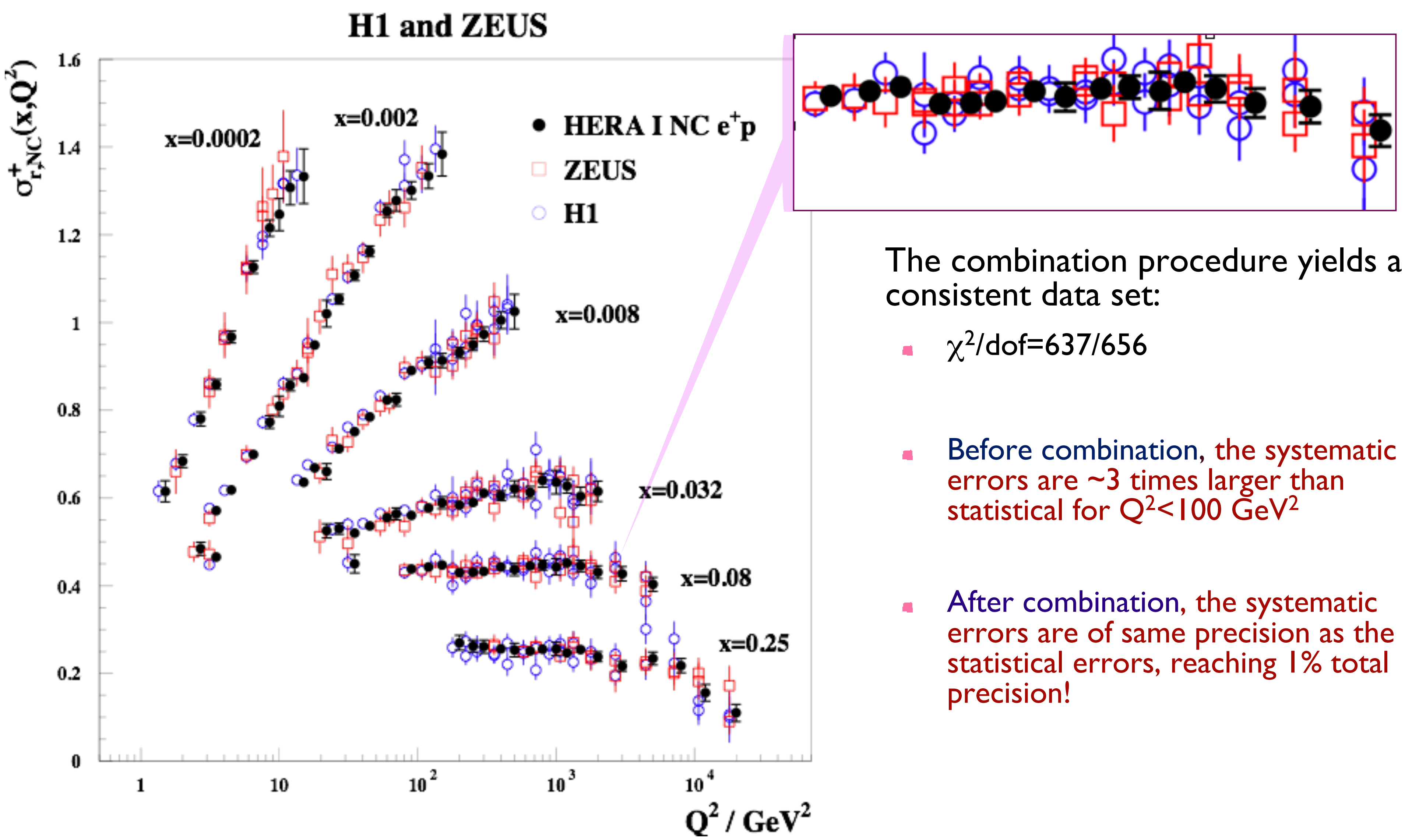
Combination of the H1 and ZEUS Measurements

[JHEP01 (2010) 109]

- Ultimate precision is obtained by combining the H1 and ZEUS measurements
- The combination procedure is performed before QCD analysis using χ^2 minimisation
  - Improvement on Statistical precision:
    - H1 and ZEUS collected similar amounts of physics data.
  - Improvement of Systematic precision:
    - H1 and ZEUS are different detectors and use different analysis techniques;
    - The H1 and ZEUS cross sections have different sensitivities to similar sources of correlated systematic uncertainty.

Results of Combining H1 and ZEUS Data

[JHEP01 (2010) 109]



The combination procedure yields a consistent data set:

- χ^2/dof=637/656
- Before combination, the systematic errors are ~3 times larger than statistical for Q^2<100 GeV^2
- After combination, the systematic errors are of same precision as the statistical errors, reaching 1% total precision!

PDF Fit Analysis Group

- Various data sets have constraining powers on PDFs:
  - Fixed Target experiments - high x
  - HERA (ep collider) - low x
  - Tevatron (ppbar collider) - high x
  - LHC (pp collider)

- Now LHAPDF V5.8.5 (released 2nd February 2011).

	MSTW08	CT10	NNPDF2.1	HERAPDF1.0/1.5	ABKM09	GJR08/JR09
HERA DIS	✔	✔	✔	✔	✔	✔
Fixed-target DIS	✔	✔	✔	✗	✔	✔
Fixed-target DY	✔	✔	✔	✗	✔	✔
Tevatron W,Z	✔	✔	✔	✗	✗	✗
Tevatron jets	✔	✔	✔	✗	✗	✔
GM-VFNS	✔	✔	✔	✔	✗	✗
NNLO	✔	✗	✗	✔	✔	✔

From G.Watt, PDF4LHC March 2011

- Following Fit groups are active:
  - CTEQ (Coordinated Theoretical-Experimental Project on QCD)
  - MSTW(Martin, Stirling, Thorne, Watt)
  - NNPDF(Neural Net PDF group)
  - ABKM/ABM (Alechin, Bluemlein, Klein, Moch)
  - GJR/JR (Glueck, JimenezDelgado, Reya)
  - **HERAPDF (H1 and ZEUS)**
    - Different data sets
    - Deifferent parametrisations
    - Different arrangements of the perturbative series
    - Different input values for alphas, charm masses
    - Different treatment for heavy quark

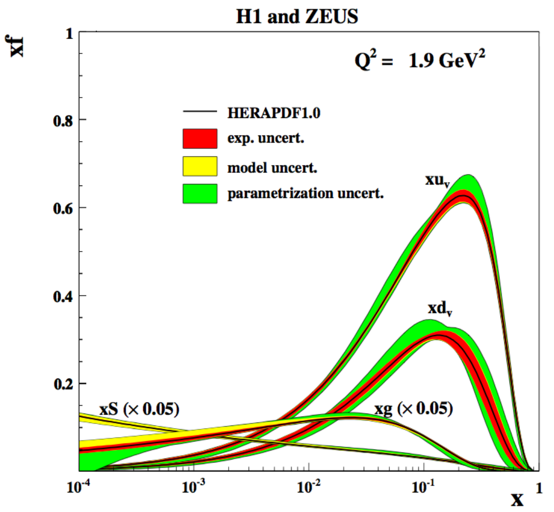
- The PDF sets from the above group can all be used for predictions and the remaining differences still needs to be studied and understood.

Sources of PDF uncertainties at HERA

- **Experimental Uncertainties:**
  - Consistent data sets → use $\Delta\chi^2 = 1$
  - Cross checked with Monte Carlo method [PDF4LHC Interim Report arXiv:1101:0536]

- **Model Uncertainties:**
  - following variations have been considered

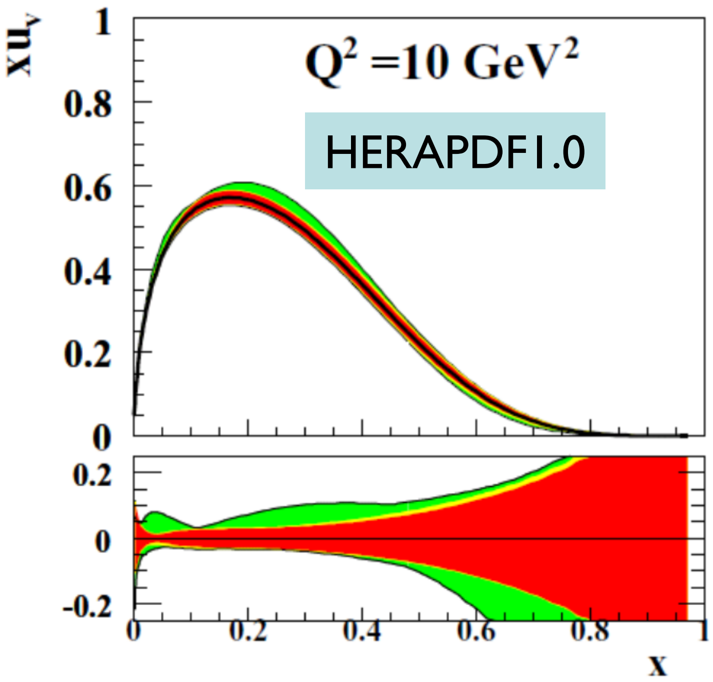
Variation	Standard Value	Lower Limit	Upper Limit
f_s	0.31	0.23	0.38
m_c [GeV]	1.4	1.35	1.65
m_b [GeV]	4.75	4.3	5.0
Q^2_{min} [GeV^2]	3.5	2.5	5.0

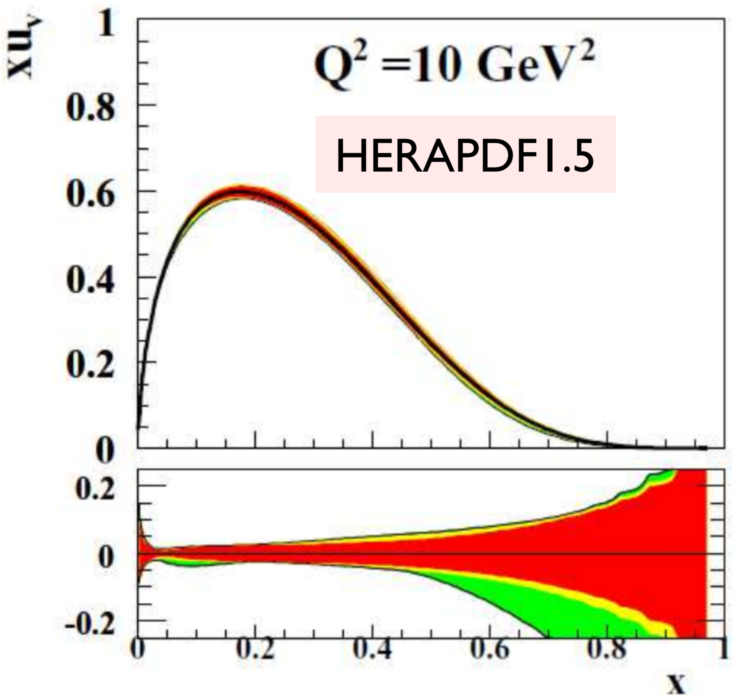


- **Parametrisation Uncertainties:**
  - An envelope formed from PDF fits using other variants of parametrisation form at the starting scale (especially sensitive to the higher x region):
    - Scanning of 11 parameter space
    - Q_0^2 variation and a more flexible gluon parametrisation
  - Studies using Chebyshev Polynomials [A. Glazov, S. Moch, VR PLB27193]

Fits to New Combined HERA data: HERAPDF1.5

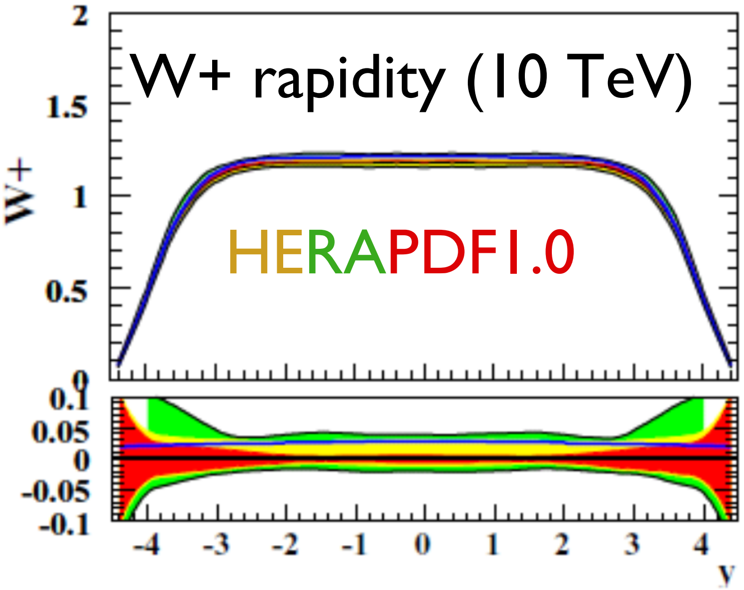
- Propagate new data through QCD fit analysis to produce a new set of HERAPDFs: HERAPDF1.5
  - For preliminary studies use same settings as for HERAPDF1.0
  - Parametrisation uncertainty will be further investigated for final release.





⇒Experimental uncertainty reduced
⇒Parametrisation uncertainty reduced

Impact of charm data on the LHC predictions

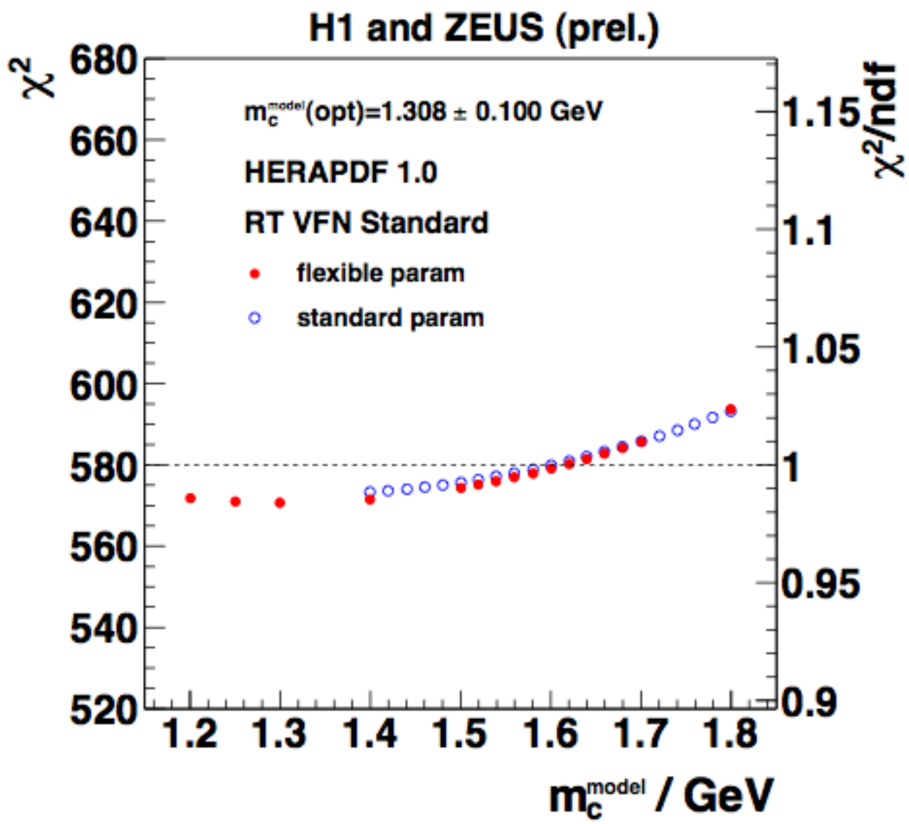


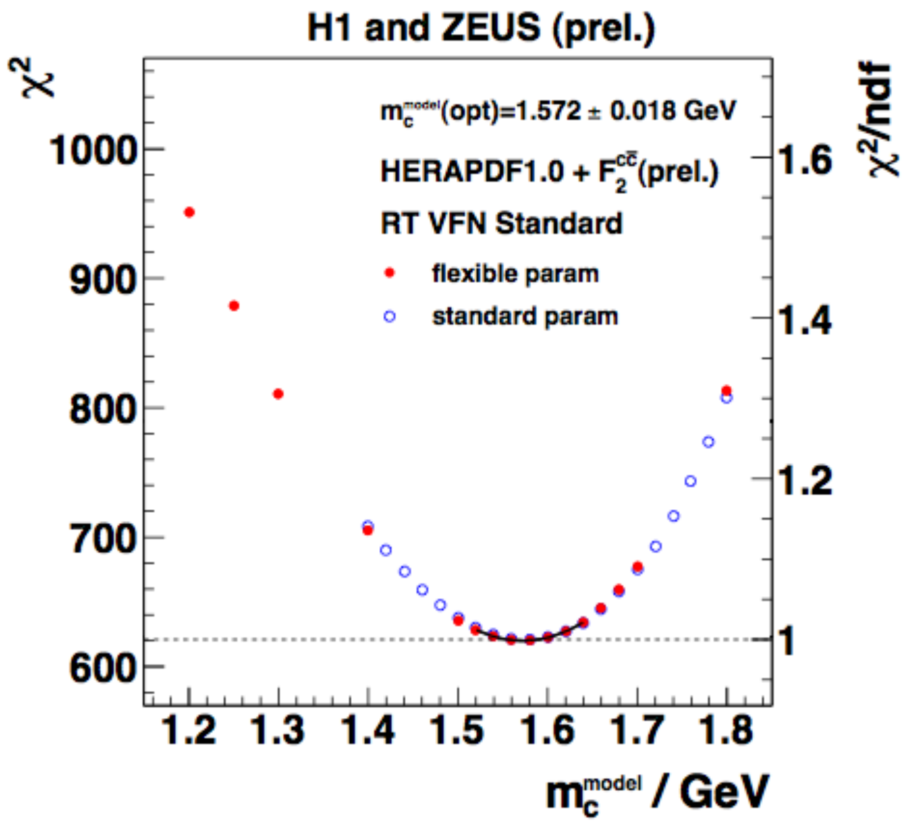
- In HERAPDF1.0, uncertainties due to heavy flavour modeling is estimated by varying $m_{c,b}$
- Predictions rise with the increased value for m_c: m_c=1.4 →1.65 GeV by 3%

- The reason for this large sensitivity is that *x* of the central W, *Z* production at the LHC is measured at HERA around the charm threshold where the contribution of F_2^c to the total inclusive F_2 is significant (up to 30%).
  - The increase in m_c leads to the suppression of xcbar in the sea distribution which is compensated by the increase of xubar.
- Recent preliminary combined H1 and ZEUS data has a precision up to 5-10% and kinematic range of $2<Q^2<1000$ GeV^2.
- The accuracy of data should allow to reduce the ambiguity in separation of Ubar type quark into xubar and xcbar contributions
  - Ubar=ubar+cbar which is fixed by F_2 data

Impact of inclusion of the charm data in the fits

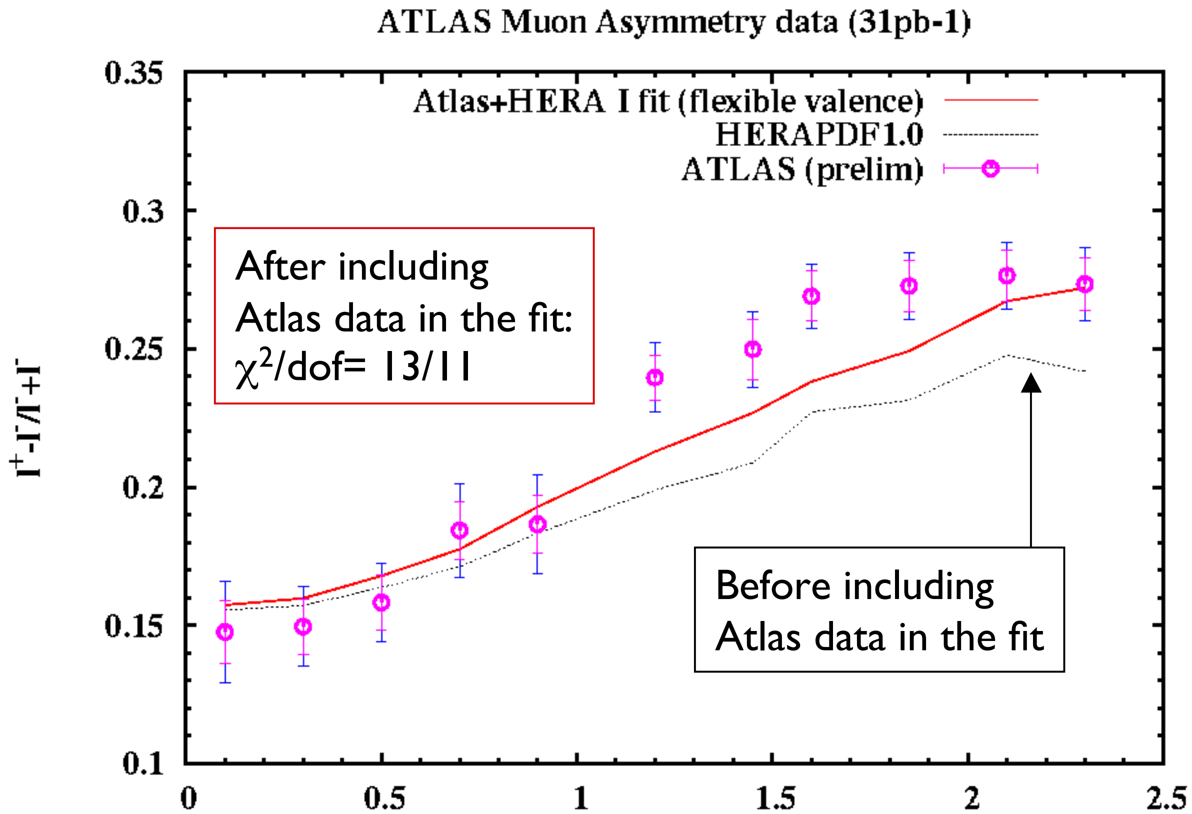
- In QCD fits without charm data similar and smaller optimal m_c are preferred for each scheme
- Strong preference for a particular m_c once charm data is included
  - Study performed for RT, ACOT, ZMVFNS schemes





Fitting LHC data

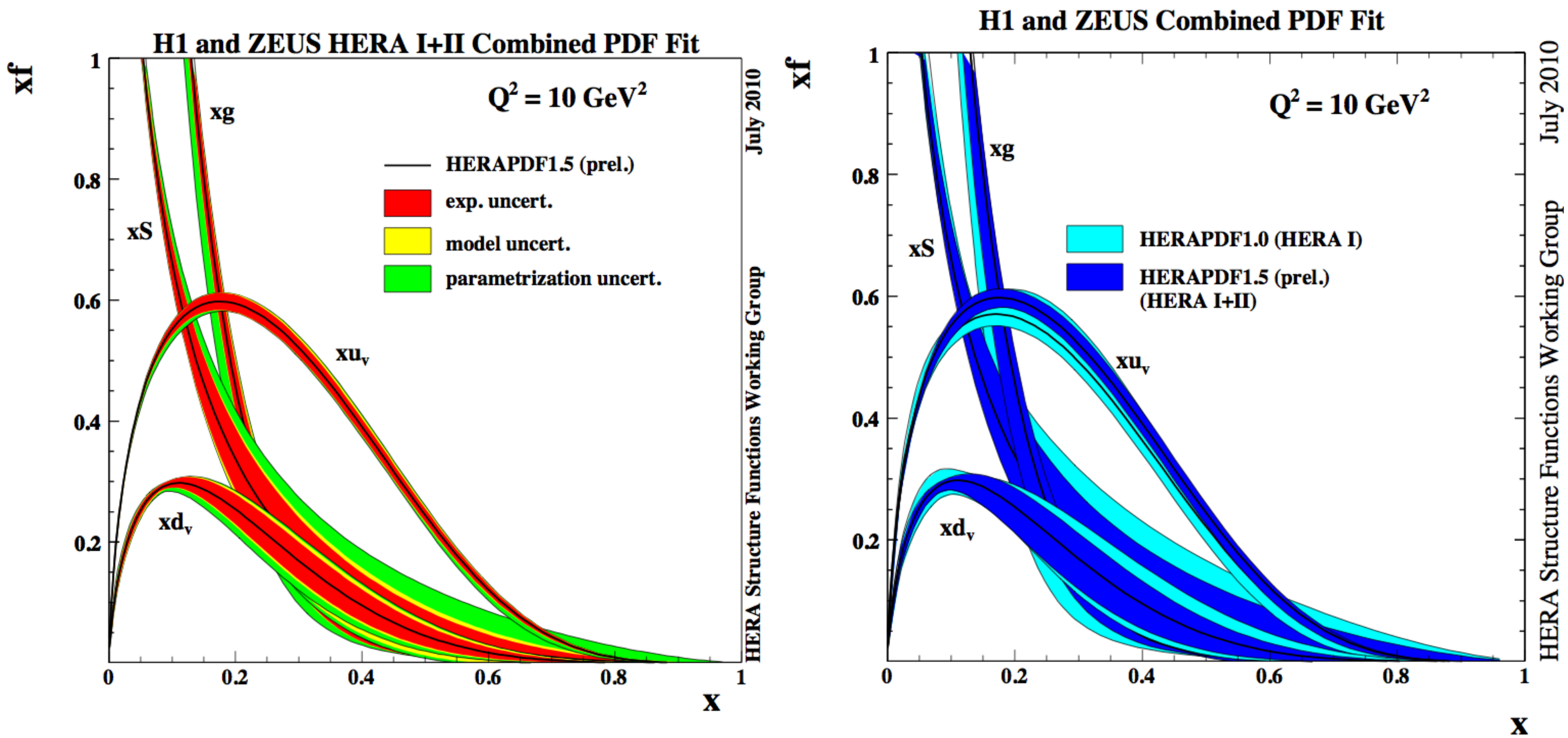
- Fitting machinery exists:
  - DIS processes at NLO and NNLO calculations
  - DY process at LO + kfactors from external sources (MCFM)
- First impact studies performed on ATLAS muon asymmetry data.



- Soon more data will be available for fits in ATLAS:
  - W, Z cross sections
  - Z rapidity distributions

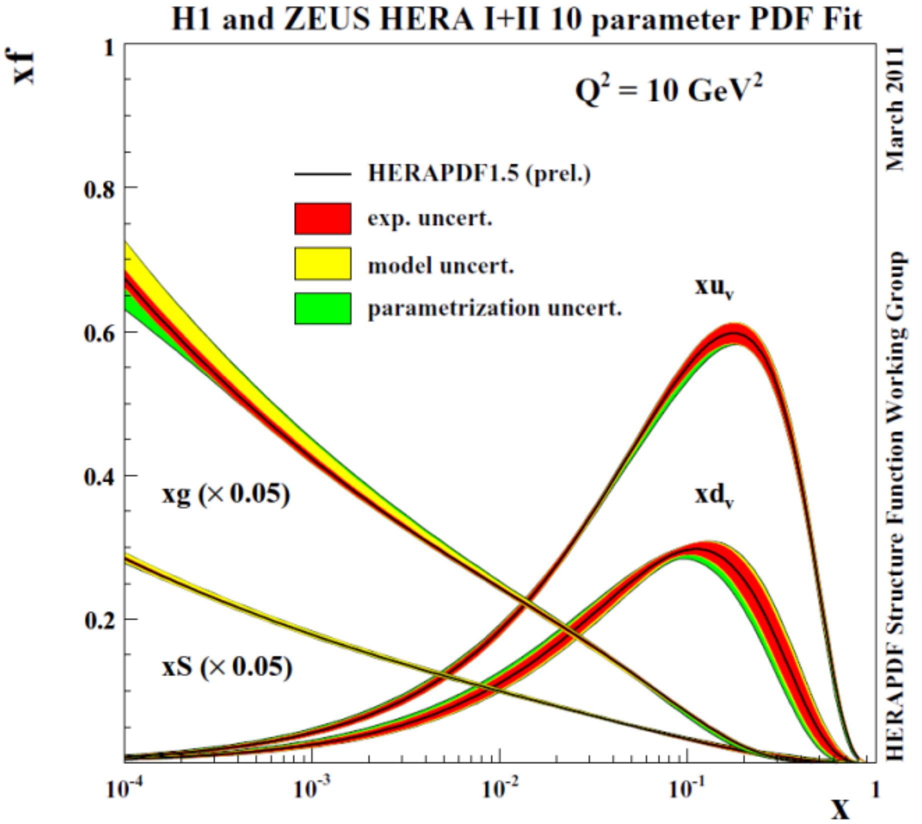
HERAPDF1.5 vs HERAPDF1.0

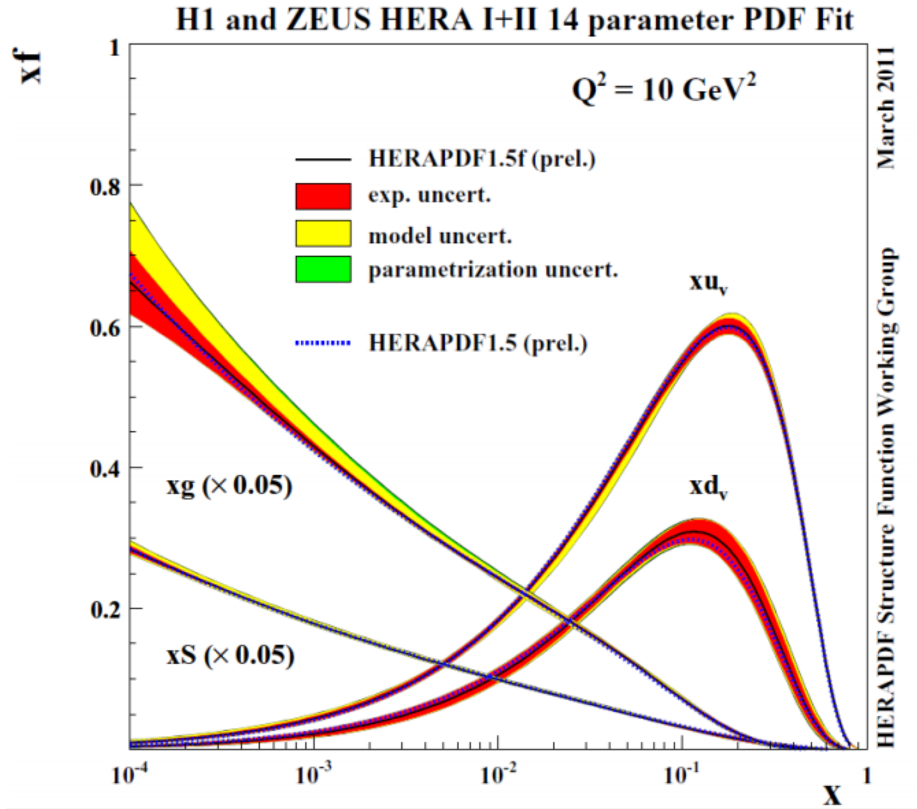
- xg, xu_v, xd_v, xS ($xS=x\bar{U}+x\bar{D}$) at the scale $Q_0^2=10$ GeV^2



- Inclusion of the HERA II data reduces the uncertainties on PDFs in the high x region especially visible on the valence distributions!
  - See HERAPDF1.5(prel) vs HERAPDF1.0

HERAPDF1.5 vs HERAPDF1.5f





Fits with and without jets (fixed alphas)