ZEUS results for ICHEP 2010 + some combined H1&ZEUS plots

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on behalf of the ZEUS and also H1 Collaborations

HERA Symposium, Hamburg, July 13, 2010

ZEUS(+H1) Results Released after EPS 2009

ZEUS papers, ZEUS preliminaries, H1+ZEUS papers, H1+ZEUS preliminaries

QCD

- Inclusive jet cross sections in DIS
- Inclusive dijet cross sections in DIS
- Inclusive jet cross sections in PhP
- Inclusive dijet cross sections in PhP
- Dijet in PhP for events with a leading neutron
- Incl. jet measurements with different algorithms in DIS and PhP
- Scaled momentum spectra in DIS
- Scaled momentum distribution for K_0s and Λ
- Prompt photons in DIS

Heavy Flavours

- F_2^c from D+
- Beauty and charm from inclusive secondary vertexing
- Beauty production in DIS using decays into electrons
- $D+/\Lambda_c \rightarrow K_0 p/K_0 p$ in DIS
- Excited charm mesons
- F_2^b in dijet+muon events
- H1+ZEUS combined F_2^{cc}
- PDF fits including the combined F_2^{cc}

EW, Structure Functions and PDFs

- CC e+p cross section with a polarized e+ beam
- NC e-p at high x
- Extension of the measurement of high-y NC cross-sections to lower Q^2
- Combined NC/CC HERAI data and QCD fits
- Combined H1 and ZEUS low energy data
- QCD fits with low energy data
- Combined high-Q^2 cross-sections from HERAII
- H1+ZEUS high pt multi-leptons
- H1+ZEUS high pt isolated leptons

Diffraction

- QCD analysis of diffractive data
- Diffractive J/Psi at high t
- Di-pion production
- Measurement of total photoproduction cross-section

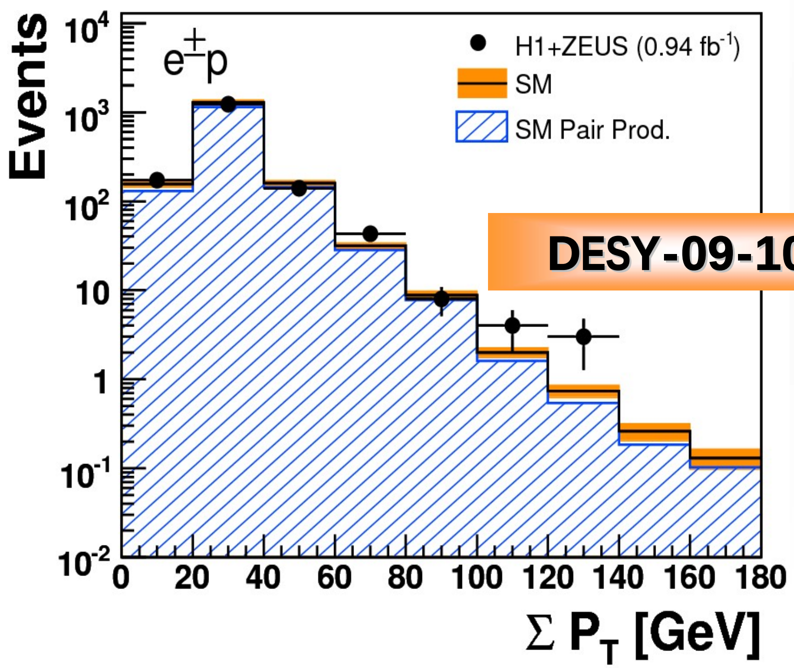
- covered in this talk

First H1&ZEUS combined papers: multi- and isolated leptons

Analysis based on the full HERA sample, L~1 fb^{-1}

High p_T multileptons

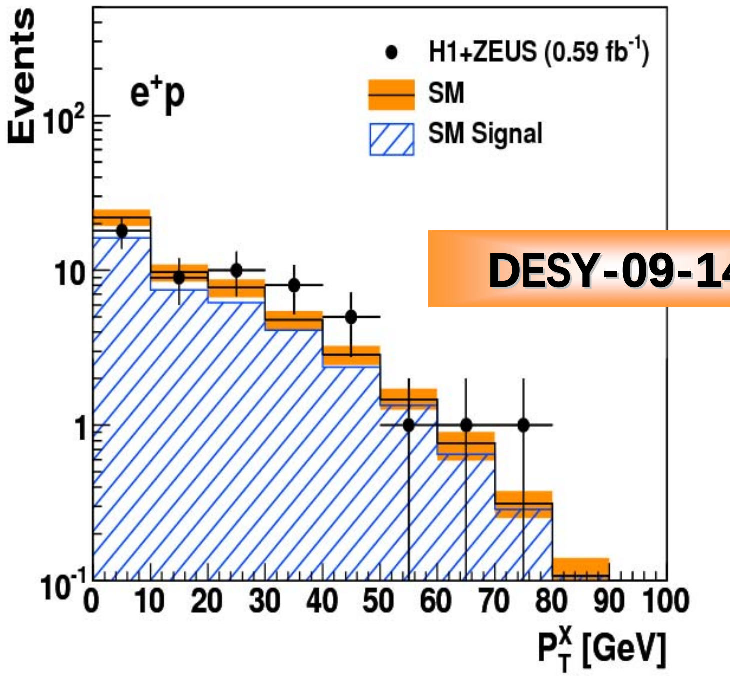
QED process → precise SM predictions → Look for deviations



Good agreement with SM predictions

High p_T isolated leptons

Dominant SM process: W production



23 high p_t^X events in e+p
14.0± 0.9 predicted

Deep Inelastic Scattering

NC: Sensitive to gluons, valence quarks and see quarks

$$\frac{d^2\sigma^{\pm}_{NC}}{dxdQ^2} \approx \frac{2\alpha\pi^2}{xQ^4}\left[Y_+F_2 \mp Y_- xF_3 - y^2 F_L\right] \qquad Y_{\pm} = \tfrac{1}{2}(1 \pm (1-y^2))$$

$$\boxed{F_2 \propto \sum_i e_i^2 (xq_i + x\bar{q}_i)} \qquad \boxed{xF_3 \propto \sum_i xq_i - x\bar{q}_i} \qquad \boxed{F_L \propto \alpha_s xg}$$

Directly sensitive to quark distribution
Gluon from scaling violations.

Valence quarks

Gluon at NLO

Use 'reduced cross section' to remove kinematic dependence:

$$\boxed{\sigma_r = \frac{xQ^2}{2\alpha\pi^2 Y_+}\frac{d^2\sigma^{\pm}_{NC}}{dxdQ^2} \approx F_2}$$

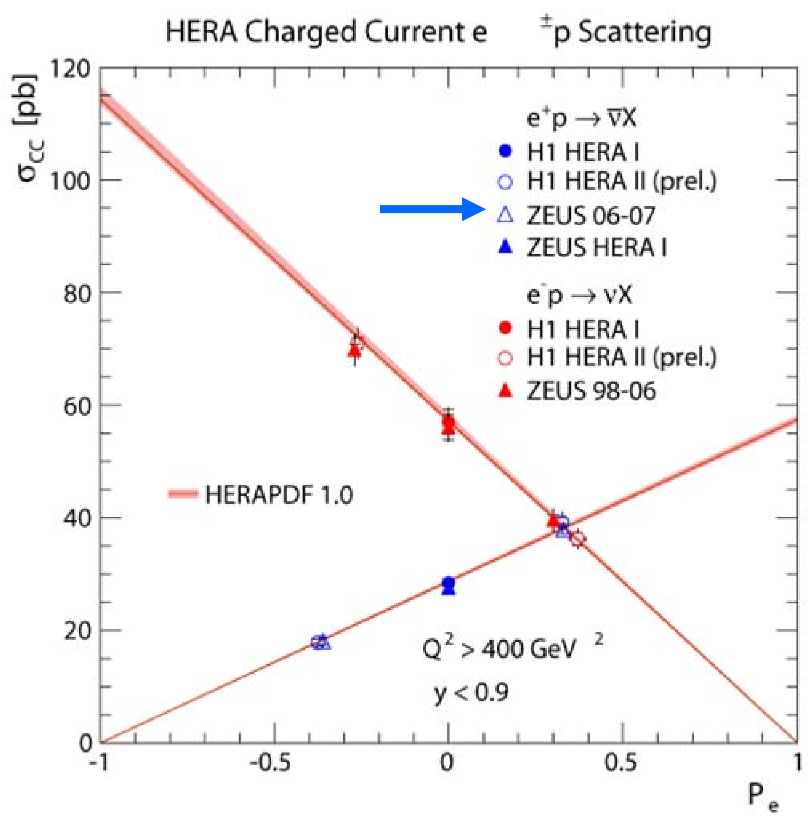
CC: Flavour decomposition

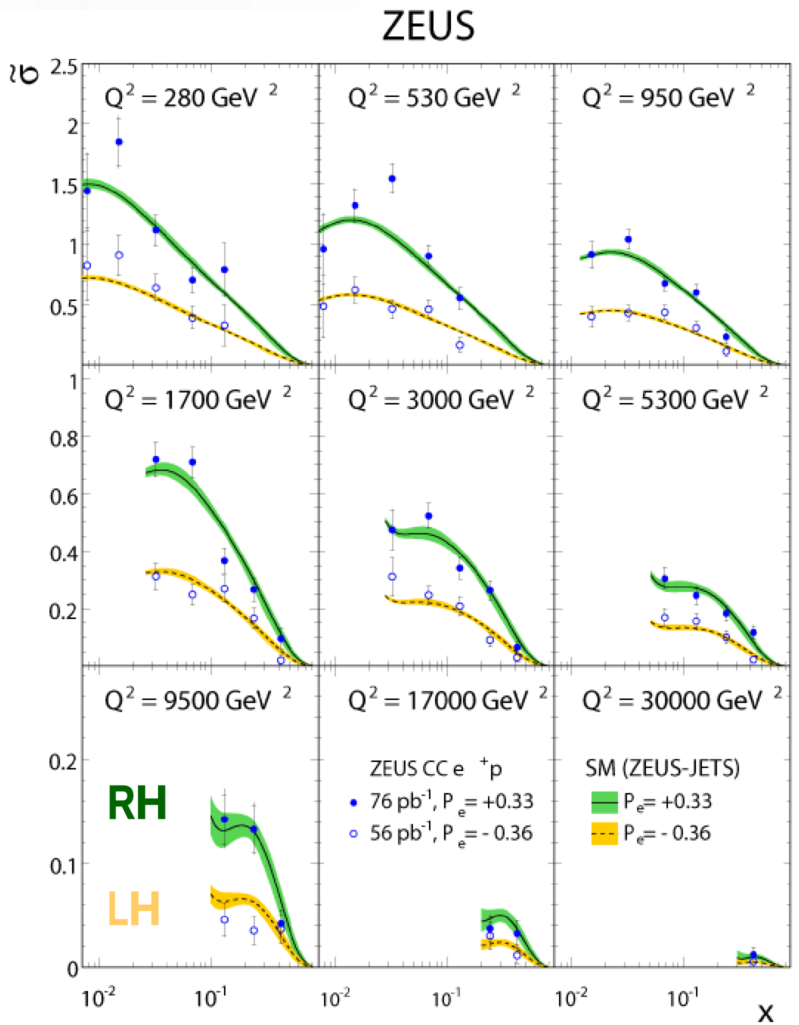
e-p: $$\frac{d^2\sigma^{-}_{CC}}{dxdQ^2} = \frac{G_F^2}{2\pi}\left(\frac{M_W^2}{M_W^2+Q^2}\right)\left[u + c + (1-y)^2(\bar{d}+\bar{s})\right]$$

e+p: $$\frac{d^2\sigma^{+}_{CC}}{dxdQ^2} = \frac{G_F^2}{2\pi}\left(\frac{M_W^2}{M_W^2+Q^2}\right)\left[\bar{u} + \bar{c} + (1-y)^2(d+s)\right]$$

High-Q^2 CC DIS with a longitudinally polarized e^+ beam

Final results on e^+p data, L=132 pb^{-1}.
$200 < Q^2 < 60000$ GeV^2
Precise input to QCD fits → high x





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Combination of the high-Q^2 data

Extension of the published combination of the HERA I data:

Method of combination:

– same as for previous HERA data combinations
(see talk by K. Daum)

Used data:

✓ **HERAI** as in DESY-09-158

✓ **HERAII**:

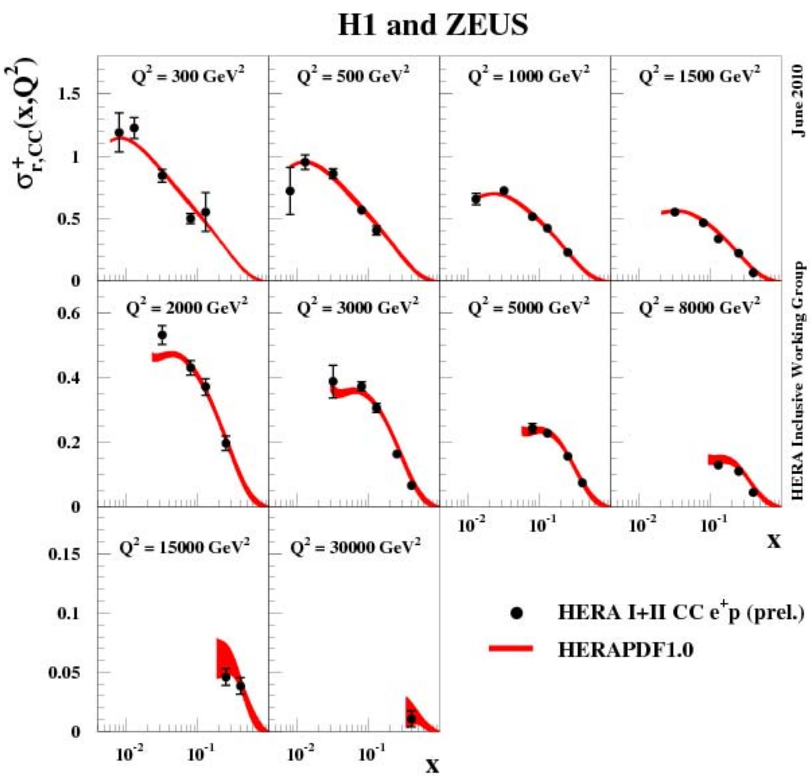
H1, HERA II (high Q^2, P=0)	**ZEUS**, HERA II (high Q^2, P=0)
CC e-p	NC e-p
CC e+p	CC e-p
NC e-p	CC e+p
NC e+p	

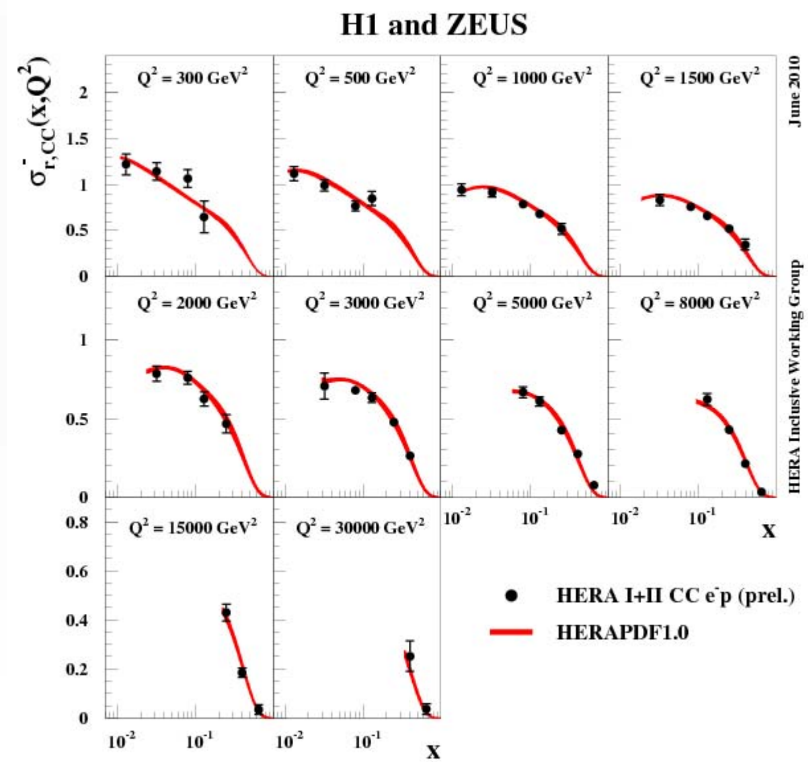
Combined HERAI+II CC data

- CC e^+p / e^-p allows to disentangle contributions of **d** and **u** quarks
- Probes flavor structure of the proton

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

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





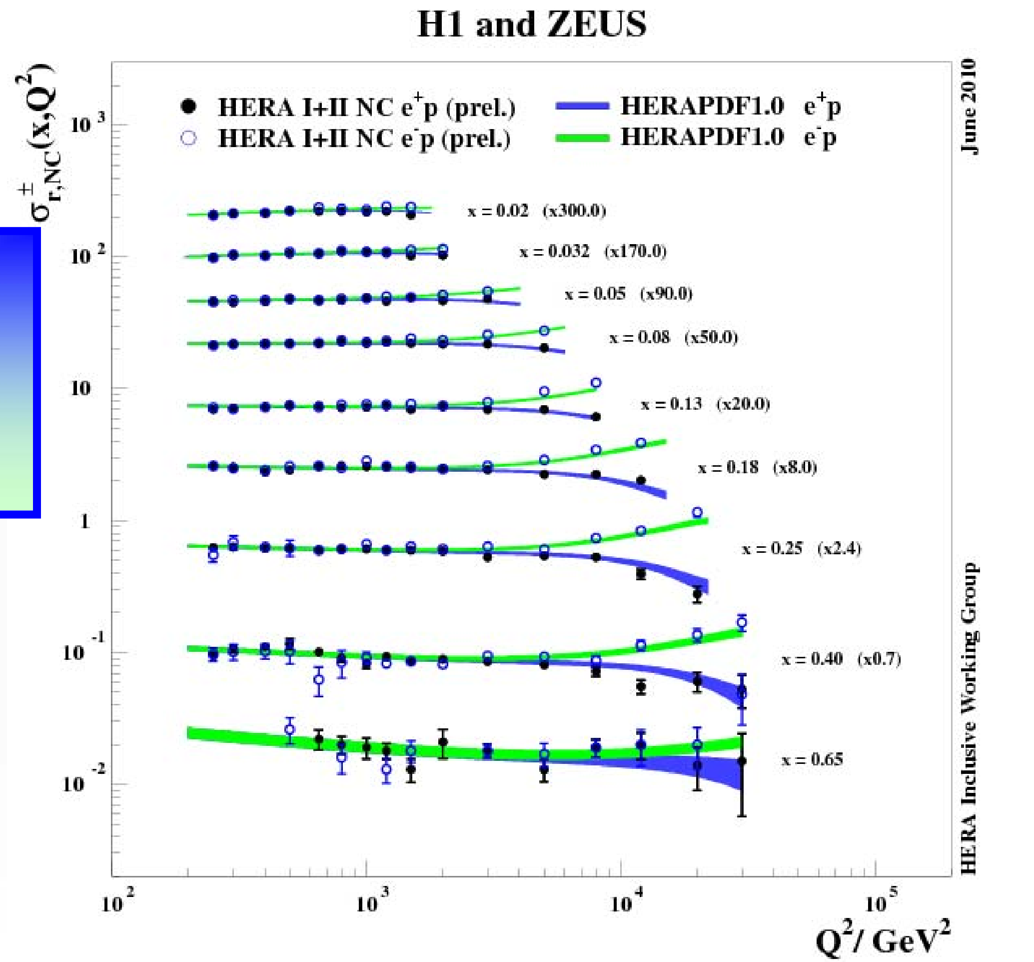
e^+p most sensitive to $d(x,Q^2)$
e^+p valence quarks suppressed by factor $(1-y)^2$

e^-p most sensitive to $u(x,Q^2)$
10 x higher statistic than in DESY-09-158

QCD analysis based on the combined data comming soon!

Combination of the high-Q^2 data

- NC data at high-Q^2:
  $Z\gamma$ interference
  destructive (e^+p)
  constructive (e^-p)

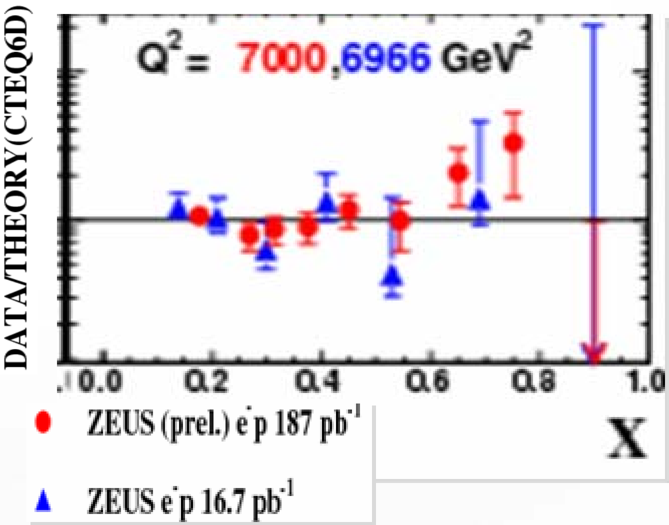


Good agreement between data and NLO QCD fit!

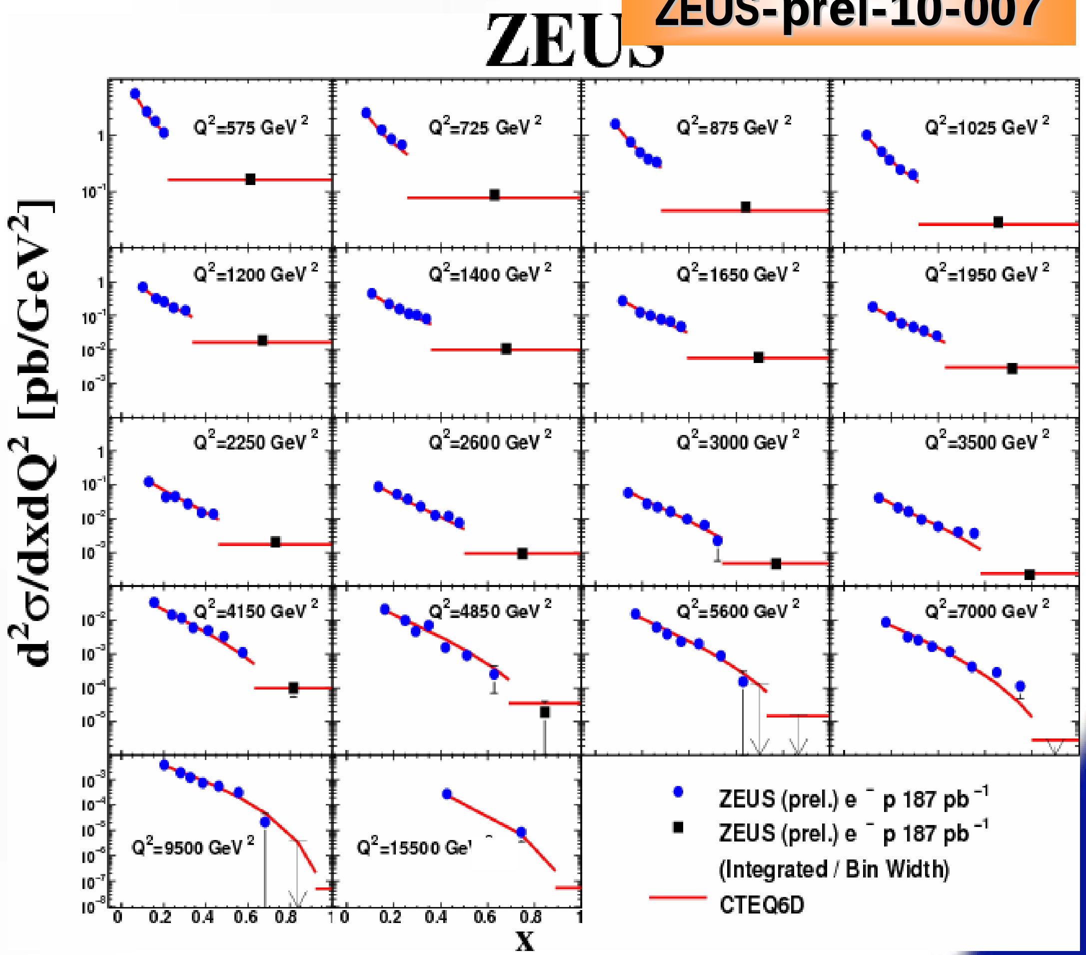
NC cross-sections at high x

HERA II e^-p data (L=187 pb^{-1})
- $Q^2>450$ GeV^2
- 0,1 and multi- jet events

- new x reconstruction method
→ leading to better resolution



ZEUS-prel-10-007



Significantly improved precision to previous ZEUS NC e^-p measurement

Sensitivity to the **high-x region**

Combined F_L measurement

ZEUS-prel-10-001
H1-prel-10-043

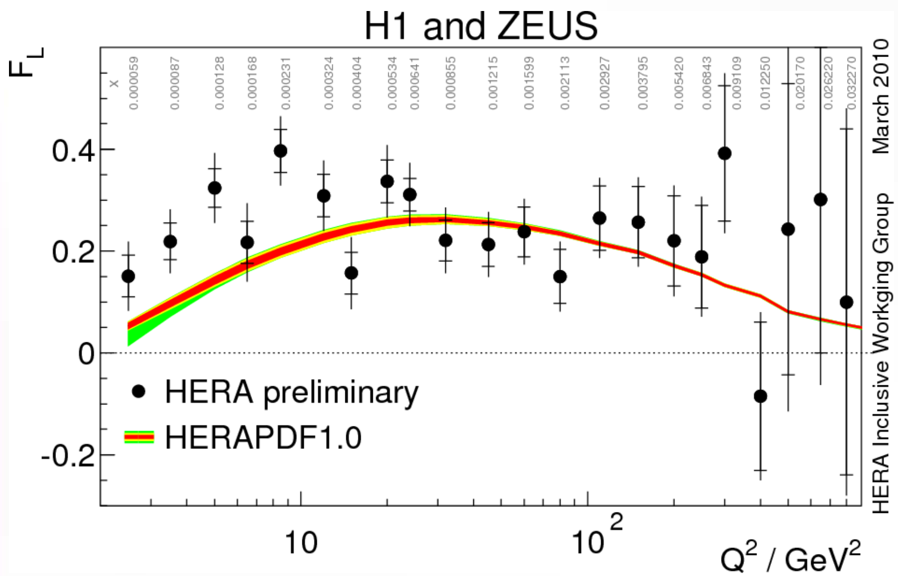
NC cross sections used for combination:

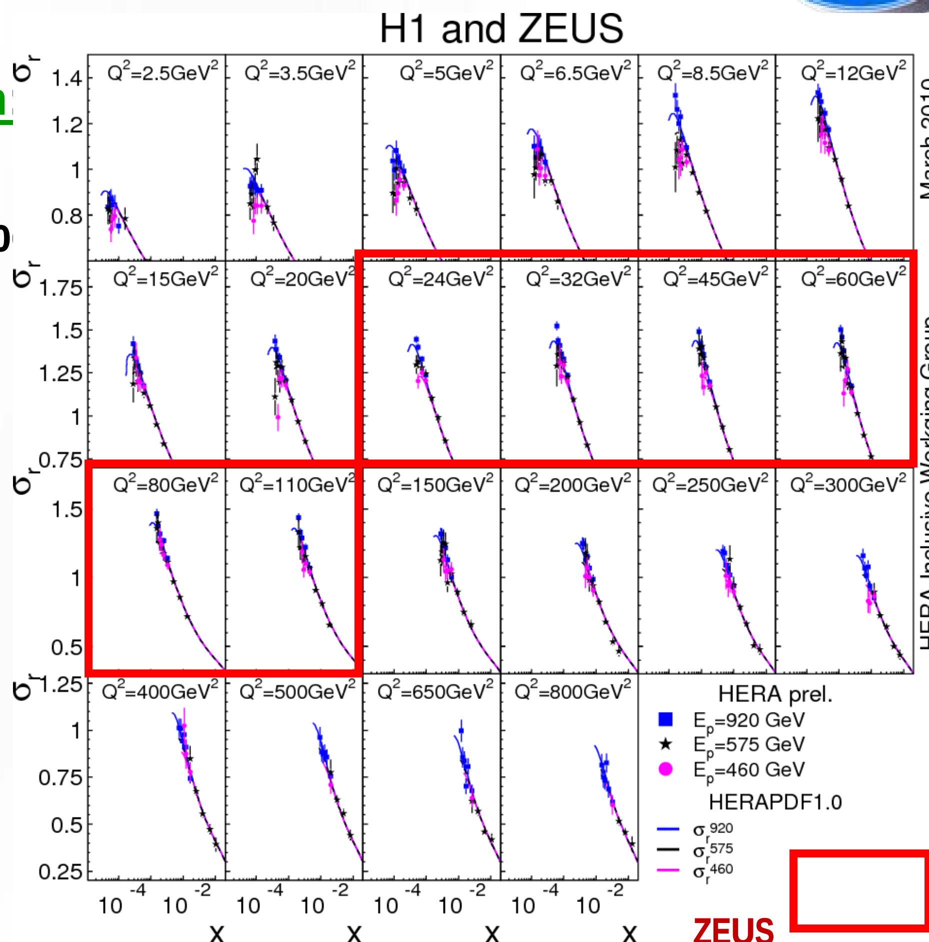
H1
$2.5 < Q^2 < 800$ GeV²
Eur. Phys. J. C63, 625 (2009)
Eur. Phys. J. C64, 561 (2009)
H1prelim: 09044,08042

ZEUS
$24 < Q^2 < 110$ GeV²
Phys. Lett. B682, 8 (20

Procedure:

– Move cross sections to common grid
– Average cross sections (minimum χ2)
– extract F_L from combined cross sections



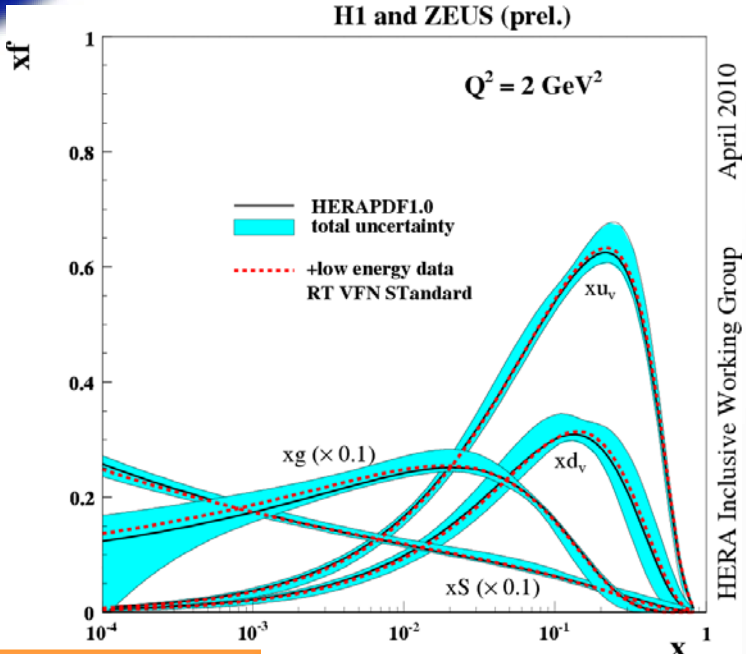


ZEUS measurement

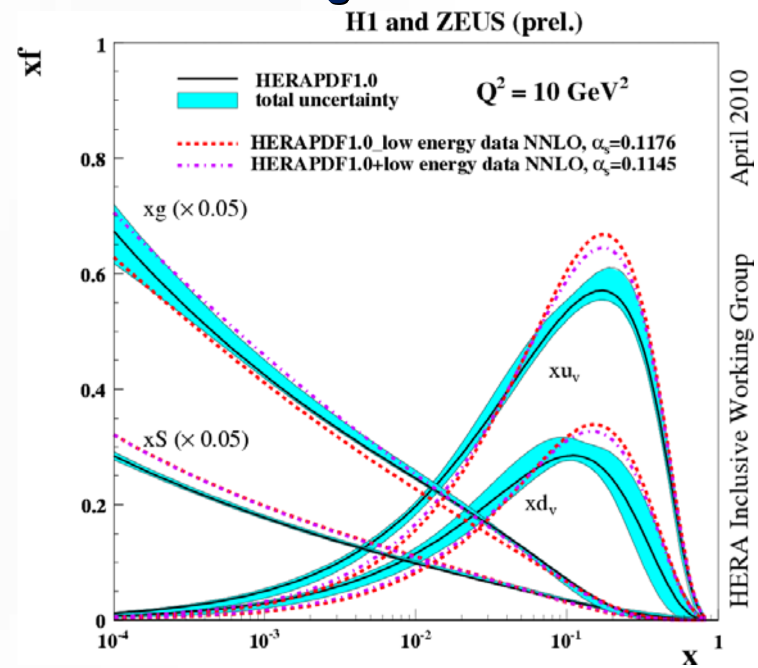
H1/ZEUS kinematic overlap region:
comparable precision→ combining data improve accuracy

PDF fits including low energy data

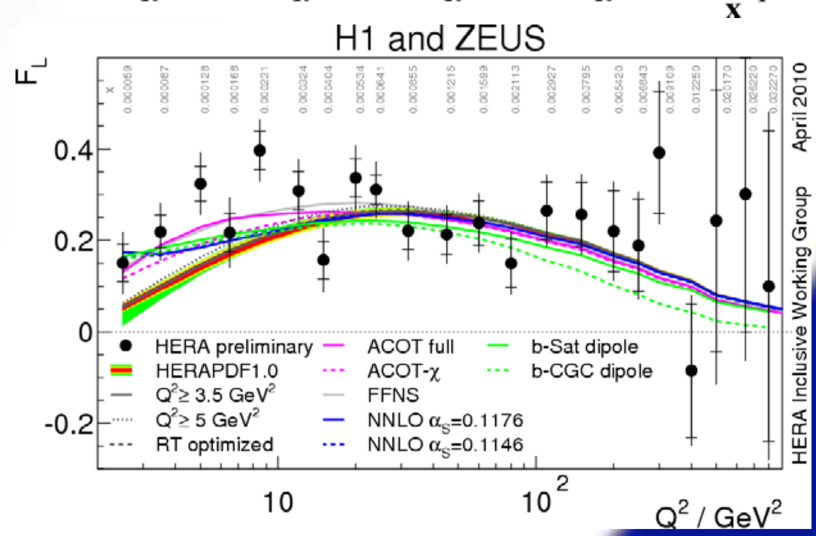
NLO PDF distribution at starting scale Q^2=1.9 GeV^2



NNLO PDF distribution at starting scale Q^2=10 GeV^2



ZEUS-prel-10-008
H1-prel-10-044



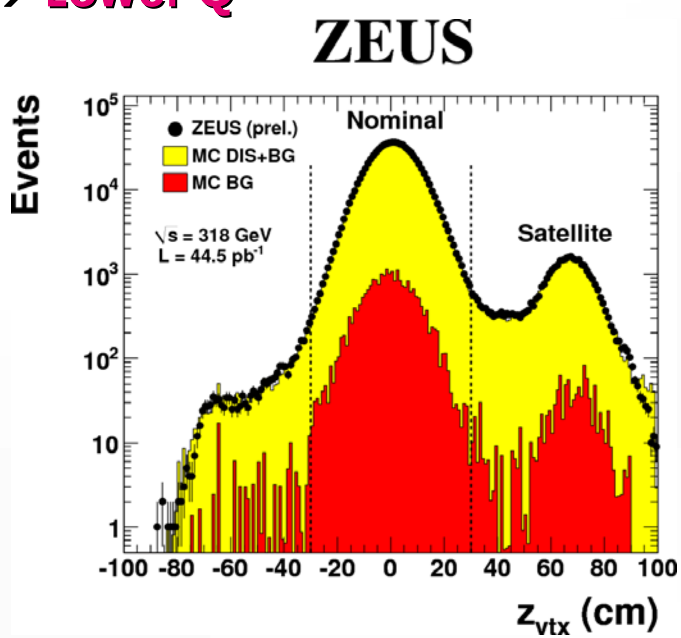
Combined F_L data vs HERAPDF fits:
- with or without Q^2 cut
- various HFL treatments
- NNLO with different $\alpha_s(M_z)$ values

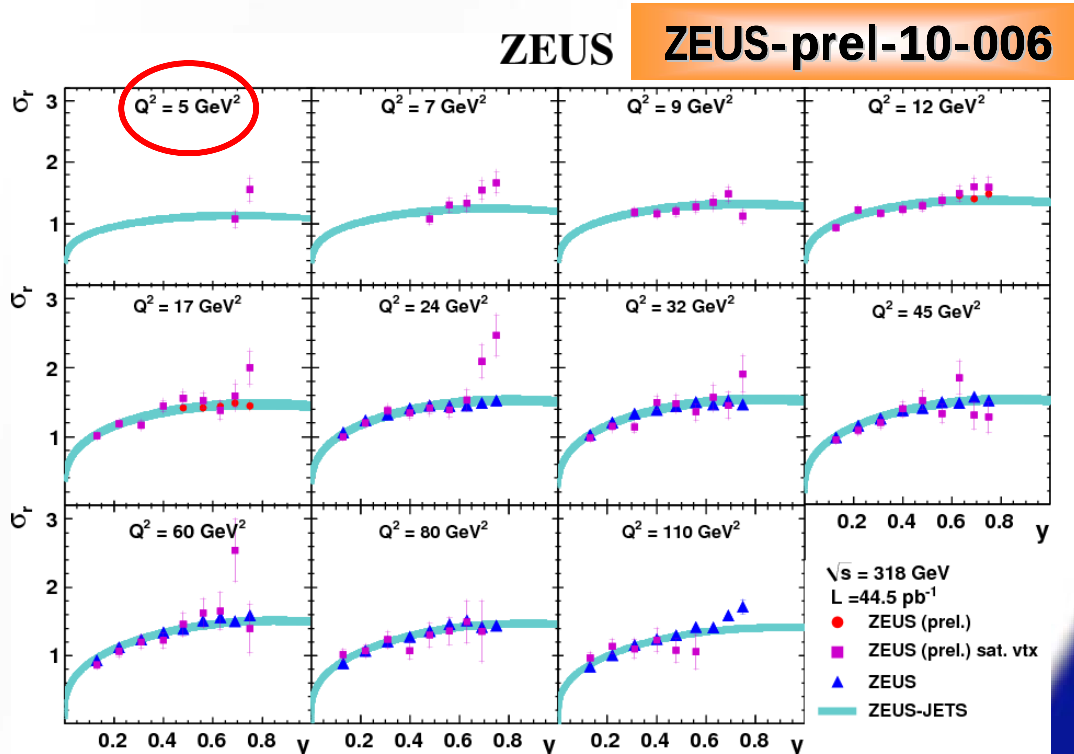
Predictions at NNLO seem to return in a better description of the F_L data

High, medium and low energy cross-section at high y

HERA NC cross sections from data collected at E_p=920, 460 and 575 GeV for the F_L determination used in PDF fits

Beam structure:
Presence of satellite vertex events can be used to access lower electron θ_{ele}
→ Lower Q^2





ZEUS extends its Q^2 region for all energies, down to 5 GeV² for HER

New ZEUS measurement can be used for further combination and QCD analysis!

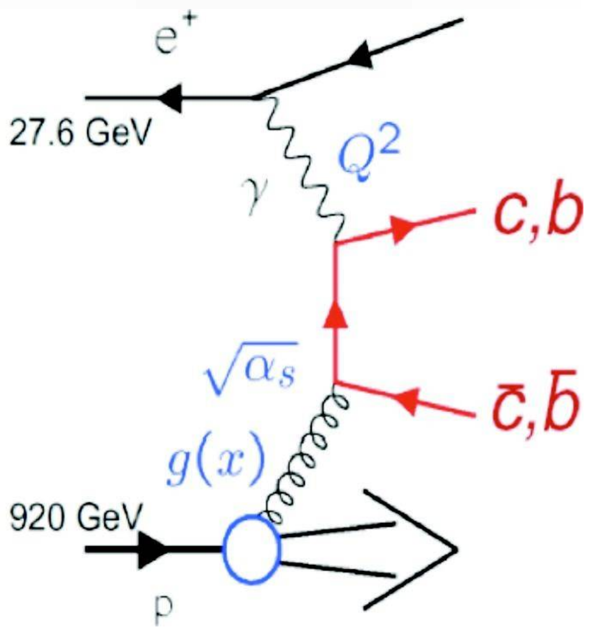
Heavy Flavours contribution to F_2

- **Beauty production in DIS**
- **Charm production in DIS**

$\left.\begin{array}{l}\\ \\ \end{array}\right\}$ **F_2 Structure Functions**

Charm and beauty production

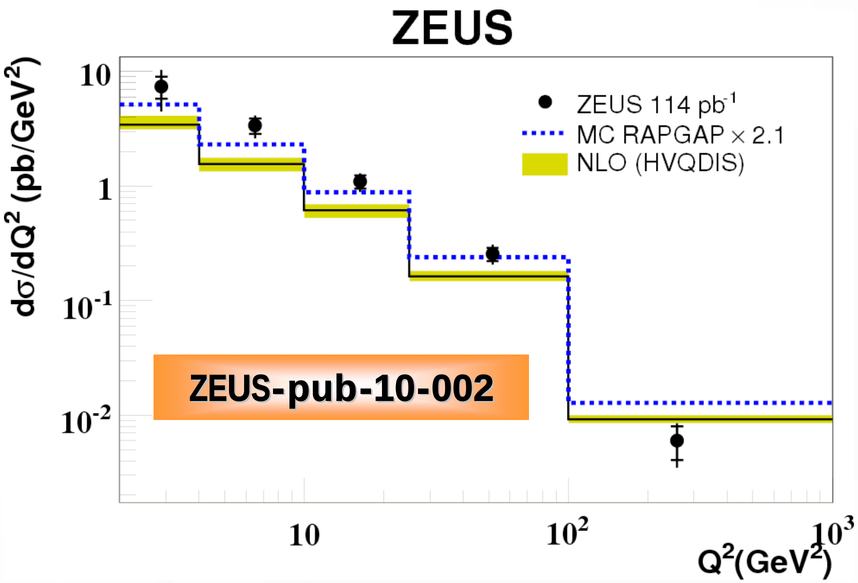
- Powerful test of perturbative QCD
- Multi-scale problem (mass, p_T, Q^2)
- Structure functions F_2^c and F_2^b → direct test of the gluon in the proton.
- Check of the QCD fits dependence on the heavy flavour treatment (see talk by K. Daum)



Beauty production at ZEUS

- Events with muon and jets, $L = 114 pb^{-1}$

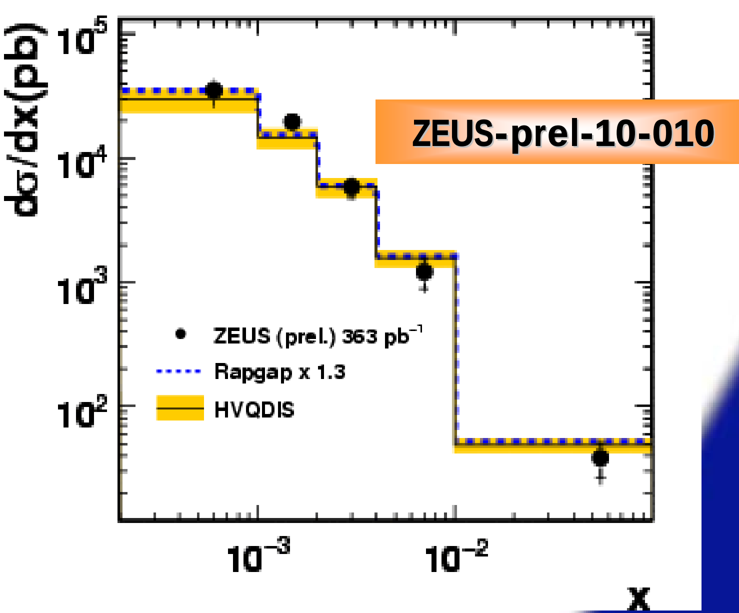
$Q^2 > 2\ GeV^2$, $0.05 < y < 0.7$
$E_T(Jet) > 5.0\ GeV$, $-2.0 < \eta(Jet) < 2.5$



- DIS events, $L = 363 pb^{-1}$

$ep \rightarrow e'bX \rightarrow e' e_{sl} \nu_e X'$
using the semileptonic $e^{\pm}$

$Q^2 > 10\ GeV^2$, $0.05 < y < 0.7$
$P_T(Jet) > 2.5\ GeV$, $|\eta(Jet)| < 2.0$



Precision of the data is limited

→ will improve using jets from secondary vertices.

Beauty in DIS with secondary vertices

Beauty reconstructed from jets with secondary vertices.

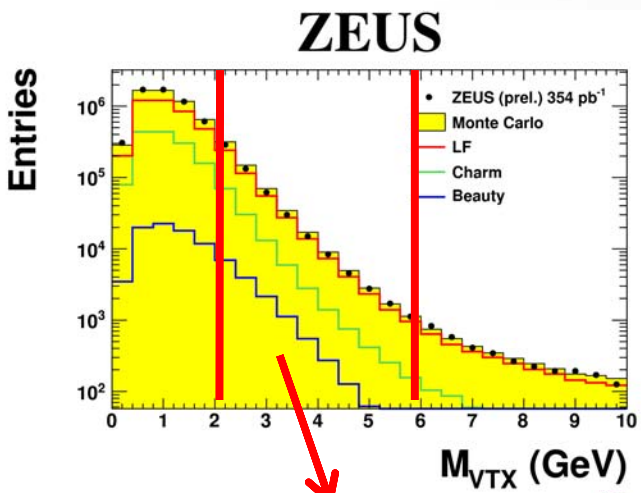
$5.0\ GeV^2 < Q^2 < 1000.0\ GeV^2$, $0.02 < y < 0.7$

$E_T(Jet) > 5.0$ GeV, $-1.6 < \eta(Jet) < 2.2$

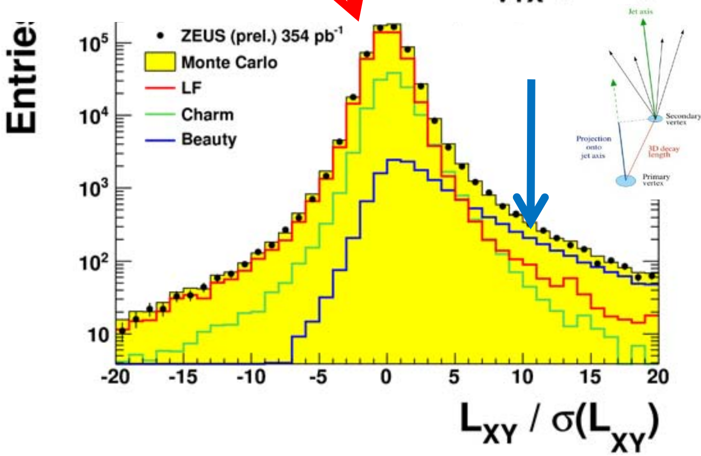
ZEUS-prel-10-004

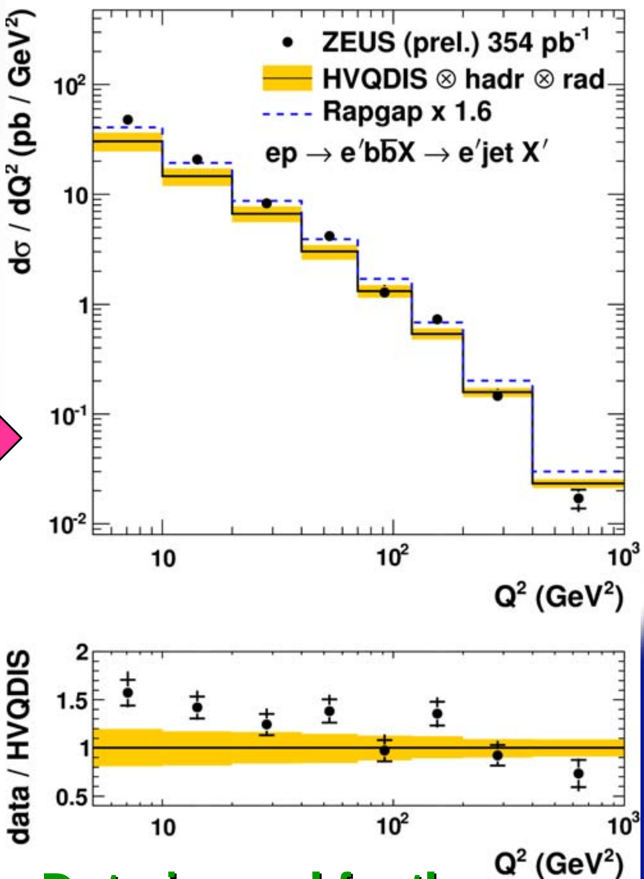
Discriminating variables:

- **Vertex mass**



- **Decay length significance**





Beauty dominant at high mass and high significance

Data is used for the extraction of F_2^b

Extraction of F_2^{bb}

ZEUS-prel-10-004

ZEUS-prel-10-010

ZEUS-pub-10-002

➢ **Cross section for bb prod. in DIS:**

$$\frac{d^2\sigma_{b\bar{b}}}{dx\,dQ^2} \approx \frac{2\alpha\pi^2}{xQ^4}\left[\left(1+(1-y)^2\right)F_2^{b\bar{b}} - y^2 F_L^{b\bar{b}}\right]$$

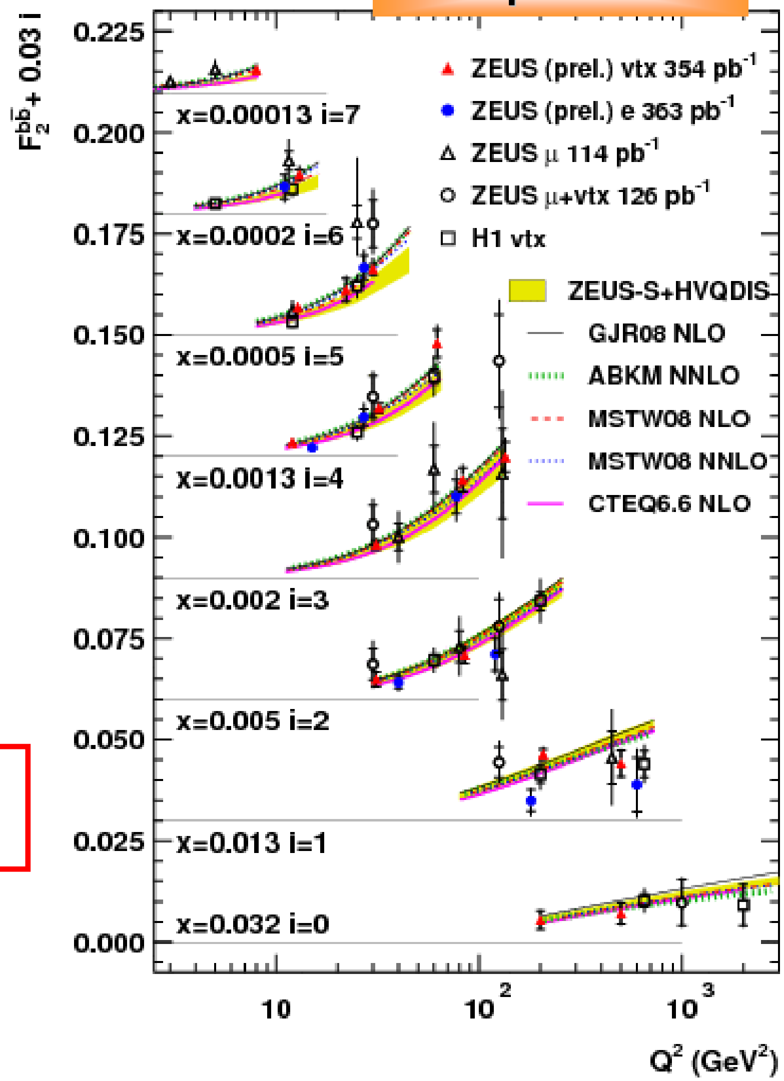
➢ **Extrapolation is needed:**

Measured cross section in bin I

$$F^b_{2,meas}(x_i, Q_i^2) = \frac{\sigma_{meas,i}}{\sigma_{theo,i}} \times F^b_{2,theo}(x_i, Q_i^2)$$

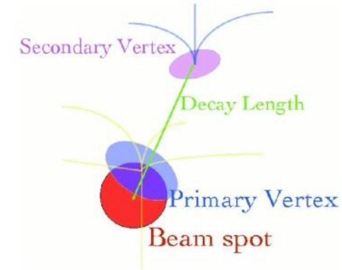
Calculated using HVQDIS (FFNS)

Calculated at NLO in FFNS



Extrapolation factors for beauty from secondary vertices very small

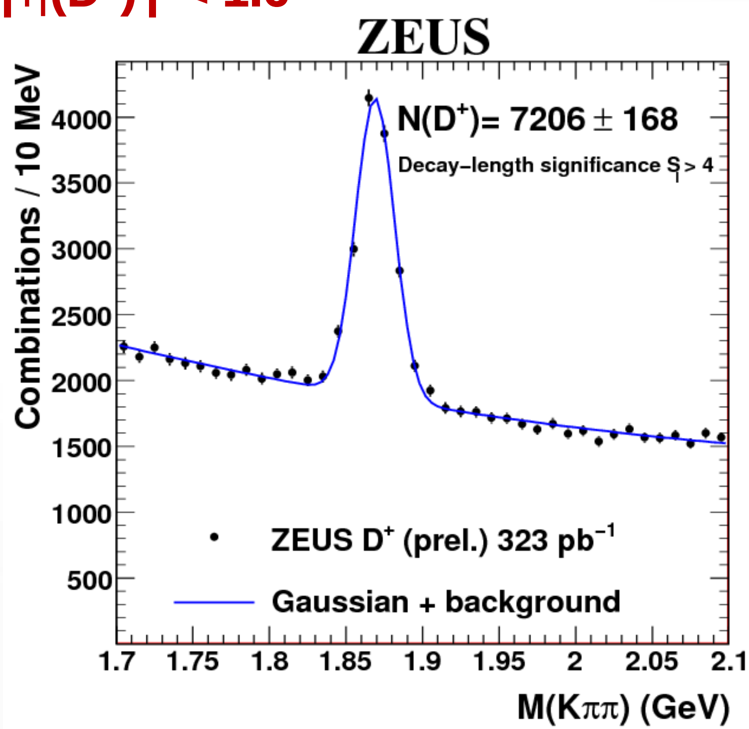
D^+ in DIS

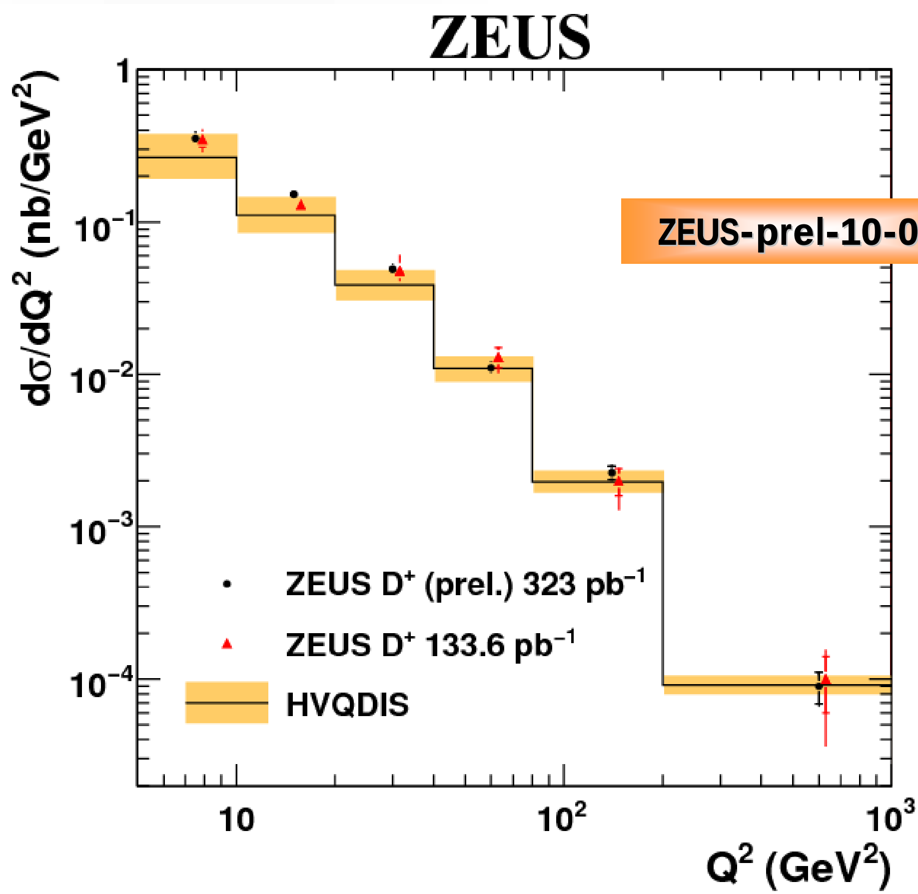


D^+ reconstructed using lifetime information. $L=323\ pb^{-1}$.

$D^+ \rightarrow K^- \pi^+ \pi^+$ (+ c.c.)

$5.0\ GeV^2 < Q^2 < 1000.0\ GeV^2$,
$0.02 < y < 0.7$
$1.5 < p_T(D^+) < 15$ GeV,
$|\eta(D^+)| < 1.6$





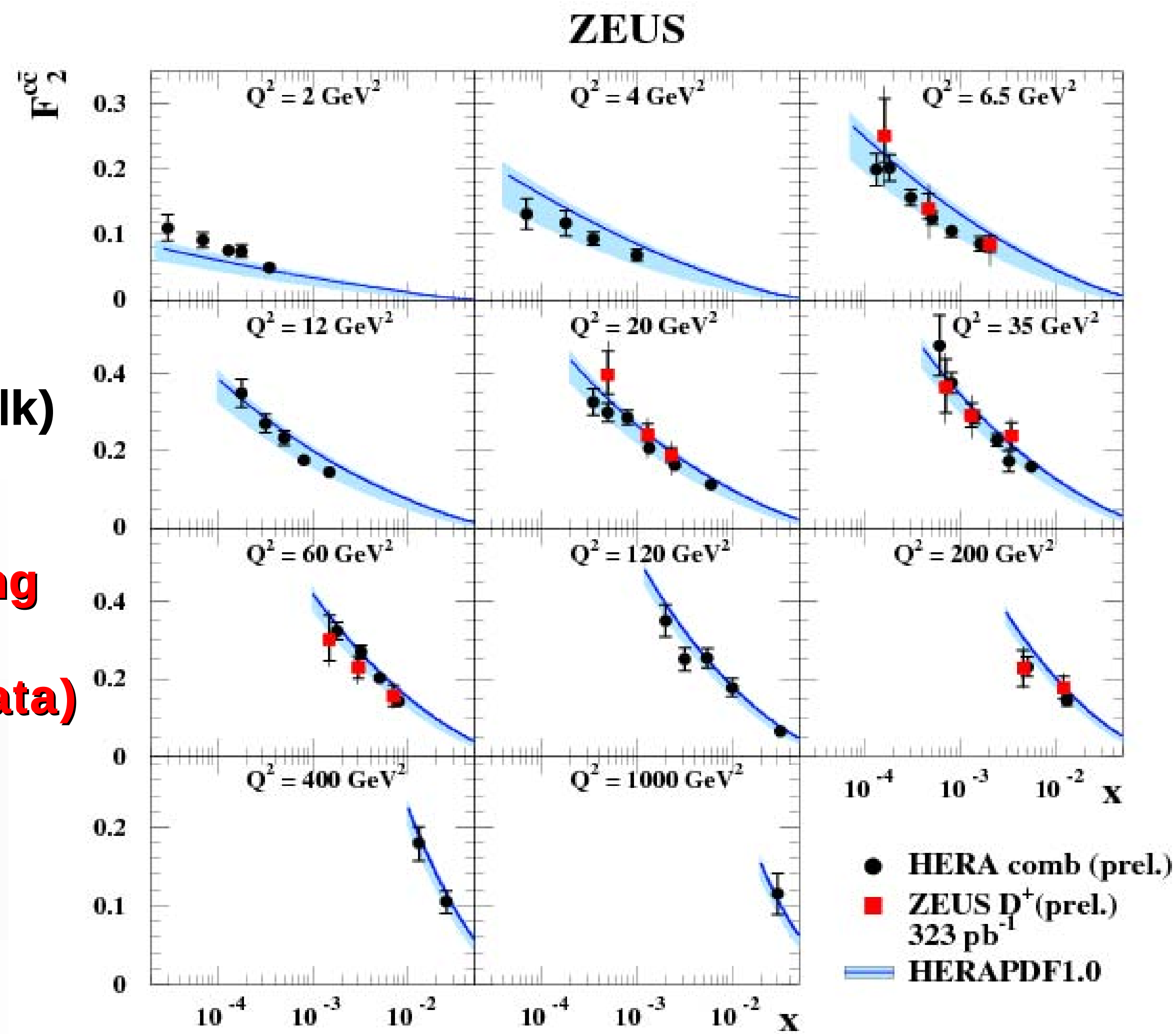
ZEUS-prel-10-005

~7200 D^+ events available

Data is used for the extraction of F_2^c

Extraction of F_2^c

ZEUS-prel-10-005



Sensitivity to the gluon.

Data from H1 and ZEUS combined (see K. Daum talk)
→ Precision is now 5-10%.

Can be improved by adding new measurements (see comparison with new D^+ data)

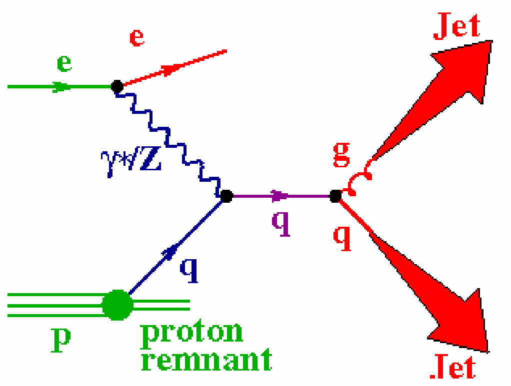
The results are well described by HERAPDF1.0 prediction

QCD and Hadronic Final States

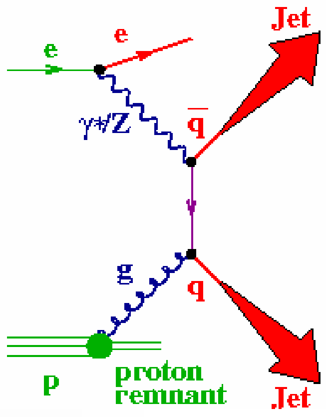
- Inclusive (di)jets in NC DIS & PhP
- Performance of different jet algorithms relevant at LHC

Jet cross-sections

- Stringent test of perturbative QCD
- Sensitivity to the gluon in the proton, precise input to QCD fits.



Boson-Gluon Fusion



QCD Compton

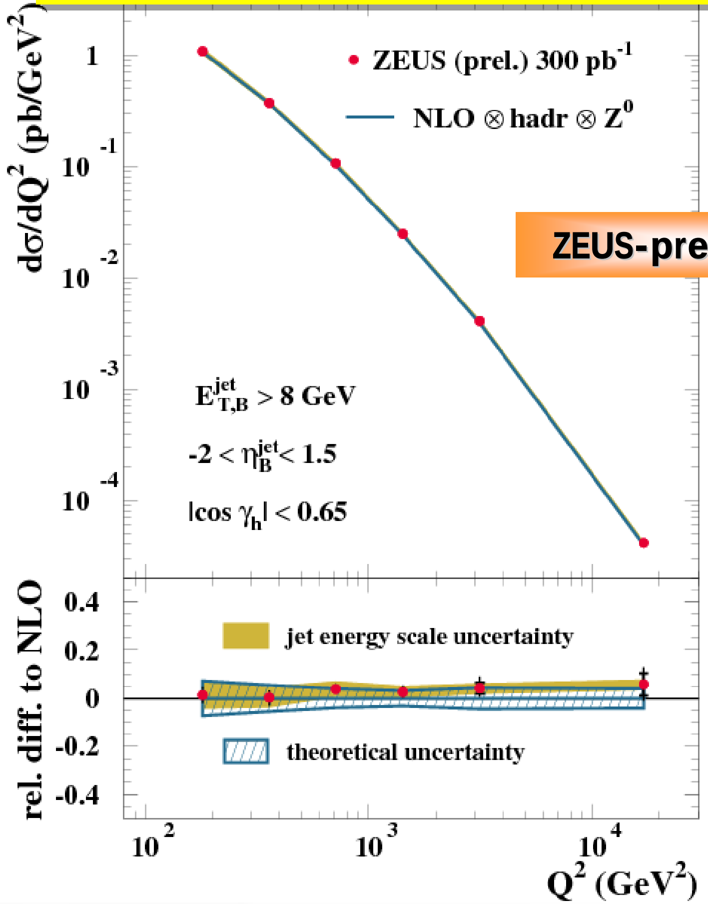
- Extract α_s with high precision, check the scale dependence within a single experiment and in different regimes.

Inclusive jets and dijets in DIS

Jets at high-Q^2 reconstructed with k_T algorithm

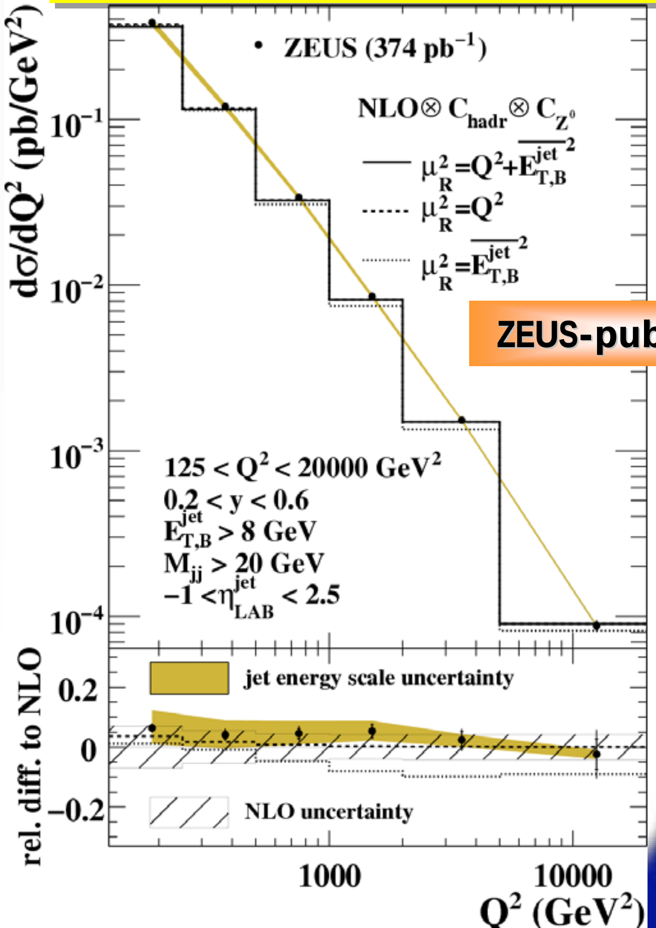
Inclusive jets, L=300 pb^{-1}

ZEUS-prel-10-002



Inclusive dijets, L=374 pb^{-1}

ZEUS-pub-10-005

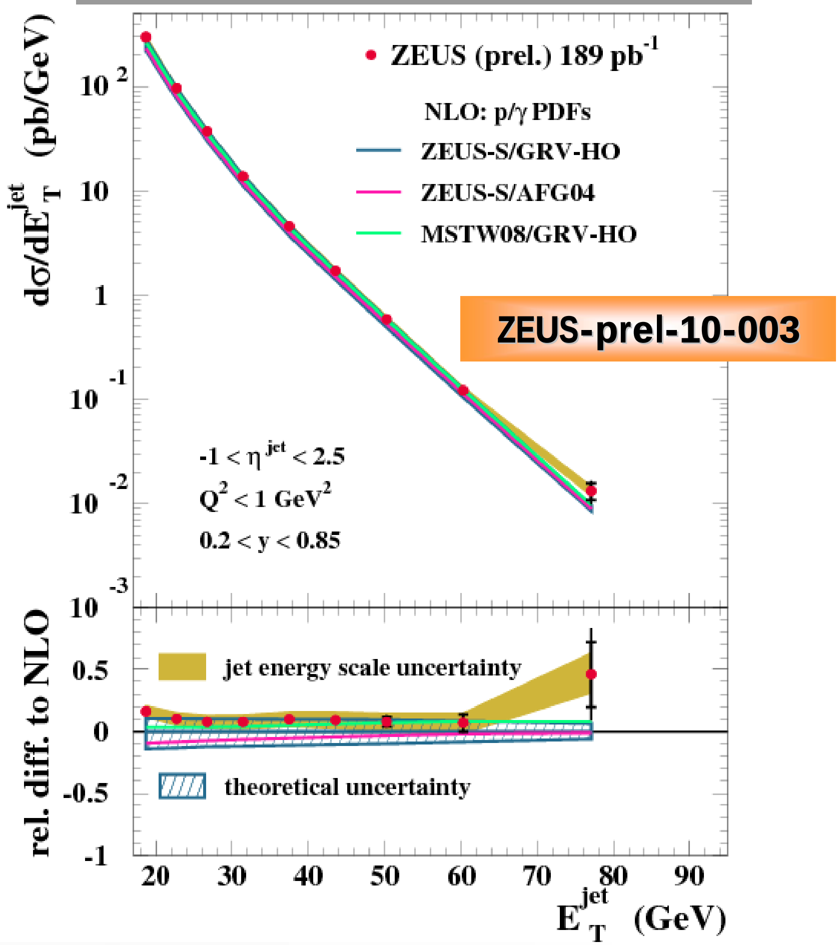


Good agreement with QCD at NLO

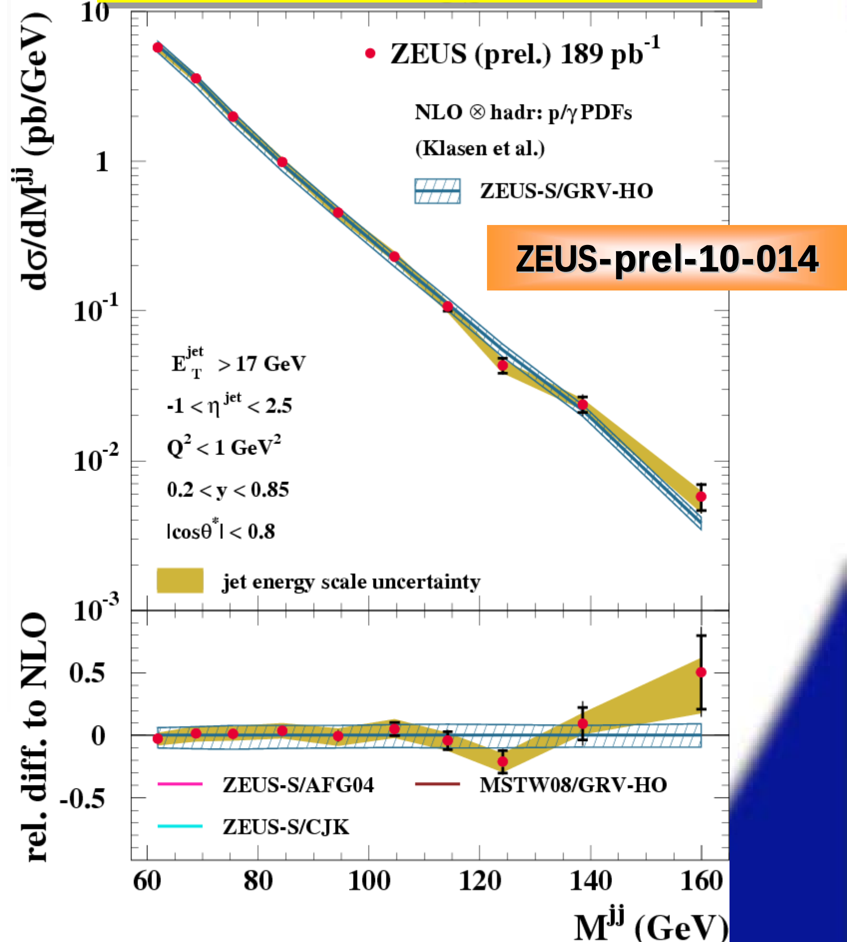
Inclusive jets and dijets in PhP

High E_T jets reconstructed with k_T algorithm

Inclusive jets, L=189 pb^{-1}



Inclusive dijets, L=189 pb^{-1}

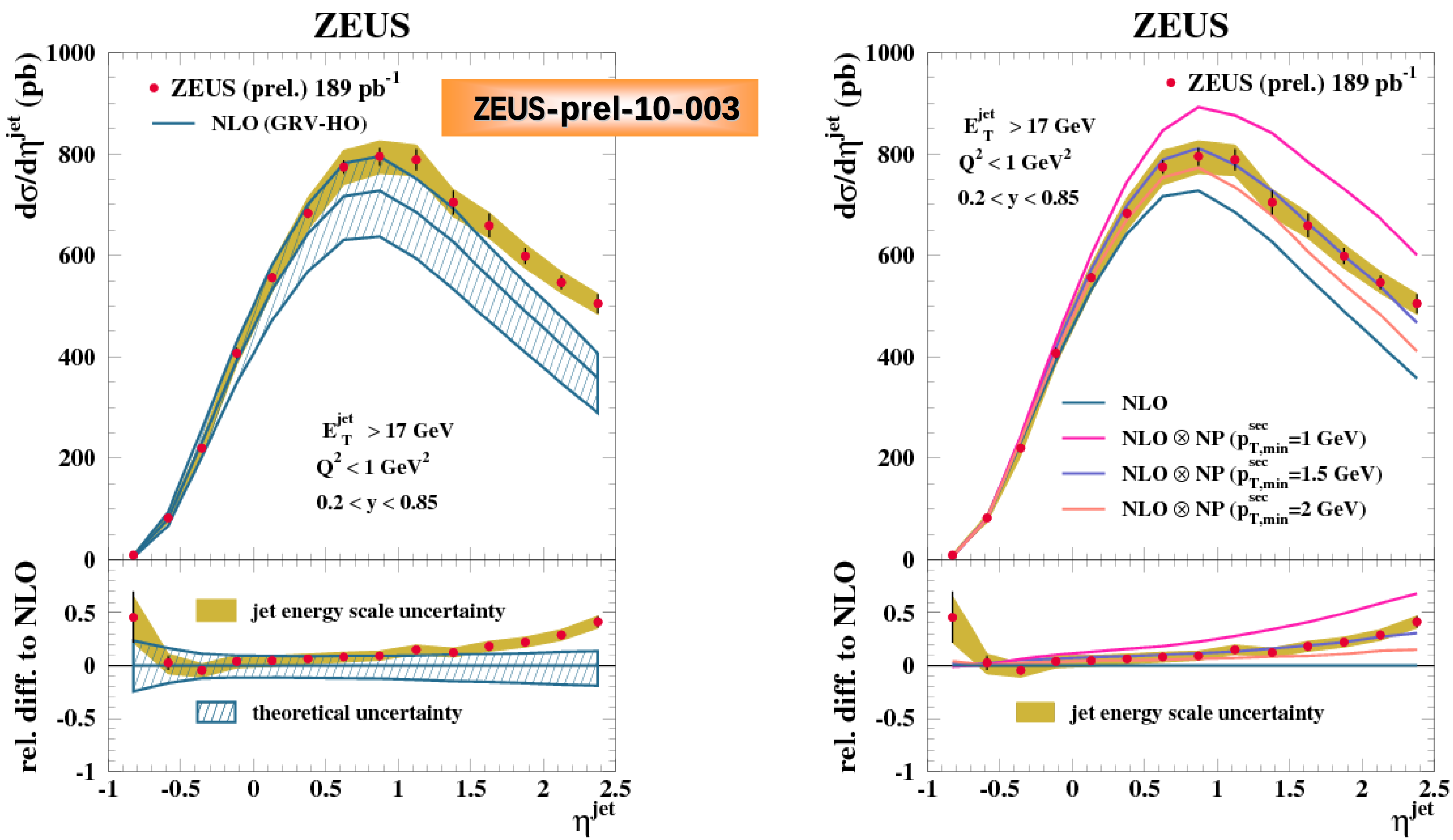


Small experimental uncertainties→
dominated by jet energy-scale uncertainty

Good agreement with QCD at NLO

Jets in PhP: non perturbative effects

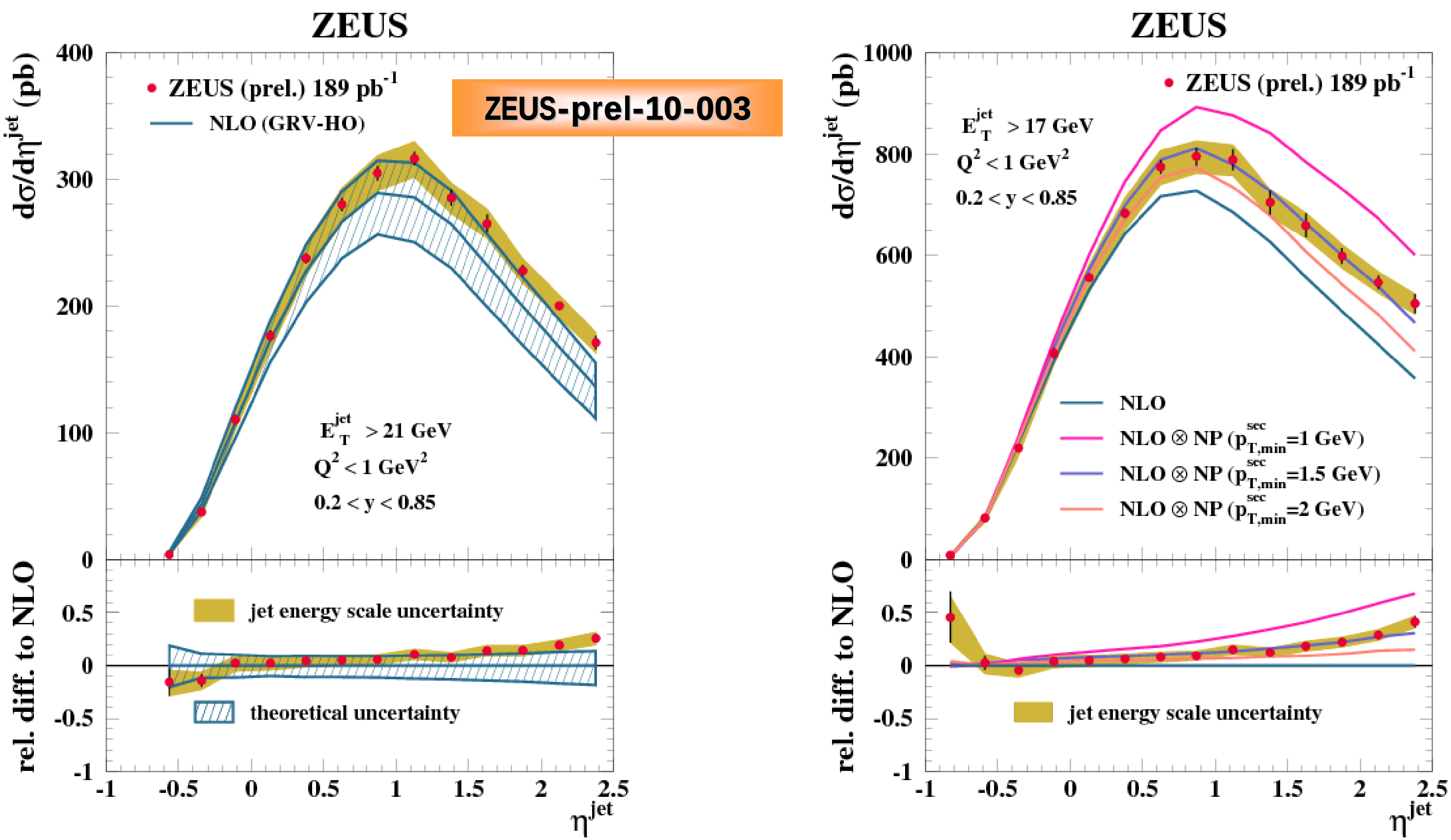
Check non perturbative effects (low E_T jet) important for LHC



- This can be also influenced by jet algorithm,
- New developments being tested for LHC
  → anti-k_T and SISCone

Jets in PhP: non perturbative effects

Check non perturbative effects (low E_T jet) important for LHC



- This can be also influenced by jet algorithm,
- New developments being tested for LHC
  → anti-k_T and SISCone

Jet algorithms

- Jet reconstruction relies on **jet algorithms**.

- Jet algorithms should not be sensitive to soft particle emission (**infrared safe**) and collinear particle splitting (**collinear safe**).

- Cone algorithms normally used in hadron-hadron collisions are **not safe at all order in QCD.**

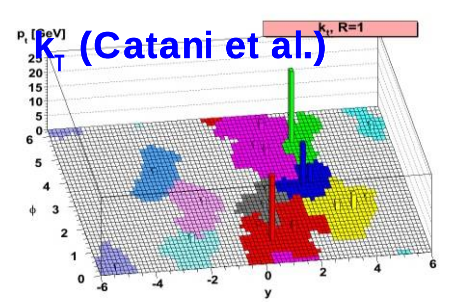
New developments:
anti-k_T (Cacciari, Salam, Soyez 08)
SISCONE (Salam,Soyez 07)
both safe at all orders

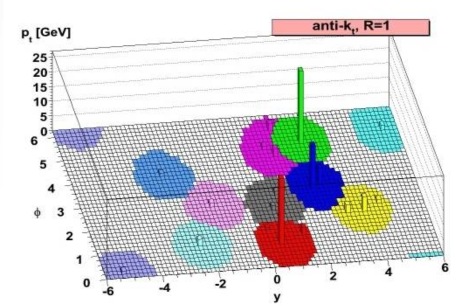
Tested on data for the first time at ZEUS

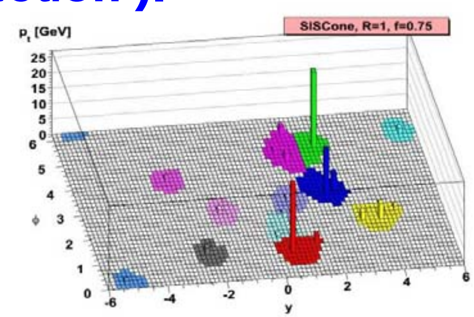
<u>Example test on the same MC event:</u>

Anti-k_T is similar to k_T but gives jets of regular shape, as SIScone (good i.e. for detector calibration, underlying events subtraction).

k_T (Catani et al.)





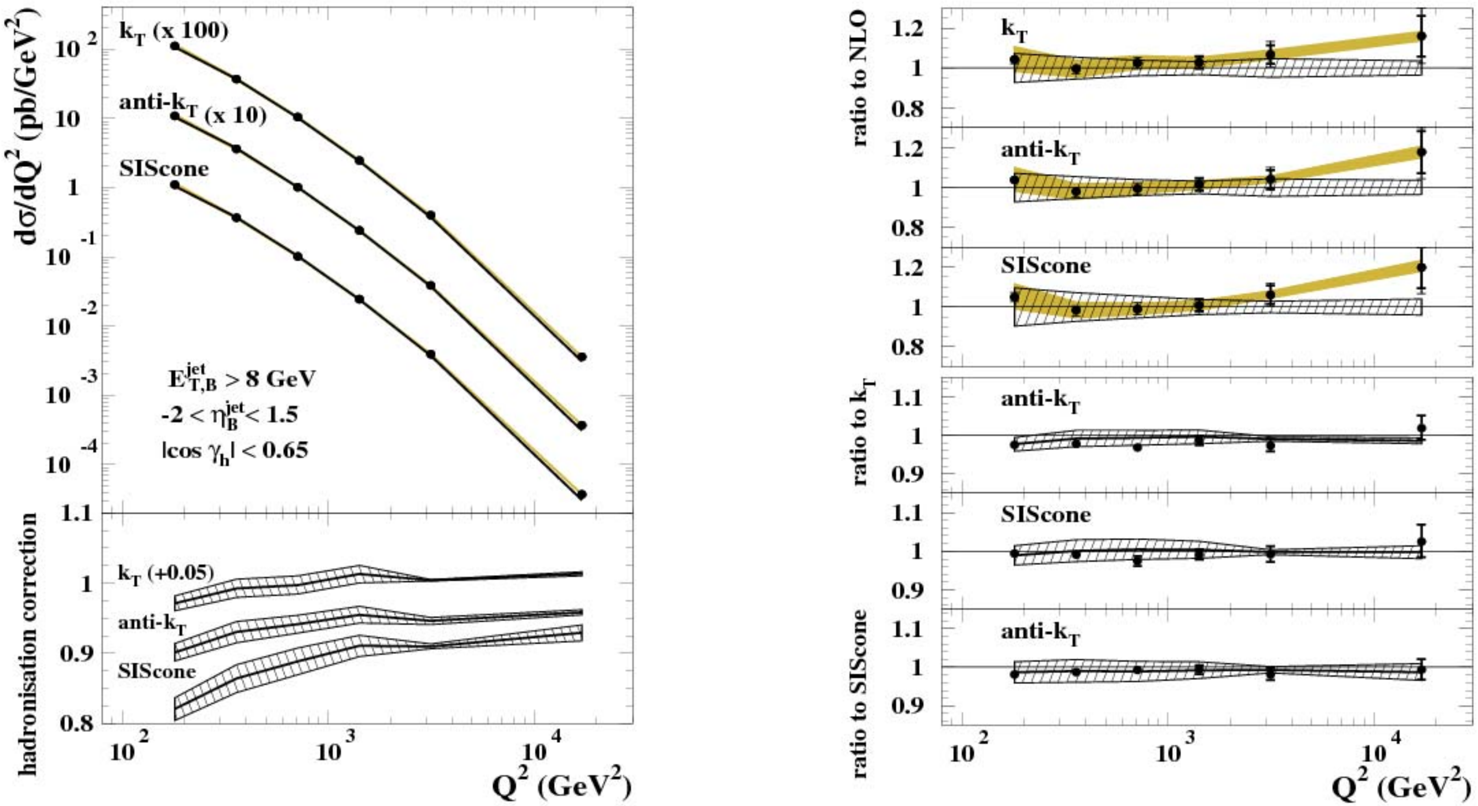


Anti-k_T and SIScone jet algorithms

Reanalysis of inclusive jets in DIS and PhP

ZEUS-pub-10-001

Jets in DIS



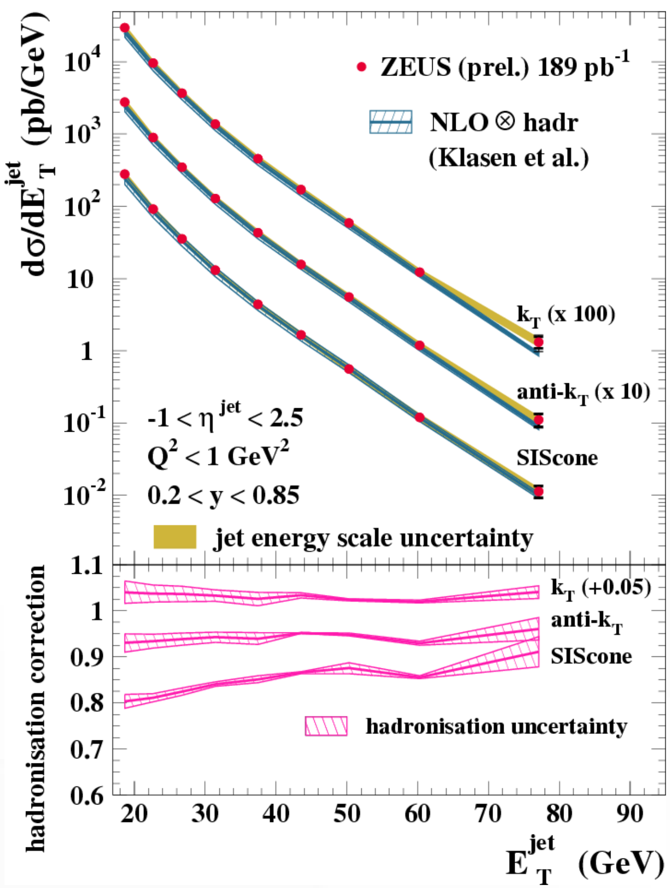
- Data very **well described by NLO** and **all the algorithms**.
- Similar precision (slightly worse for SIScone)
- Ratios evaluated up to **order α_s^3**

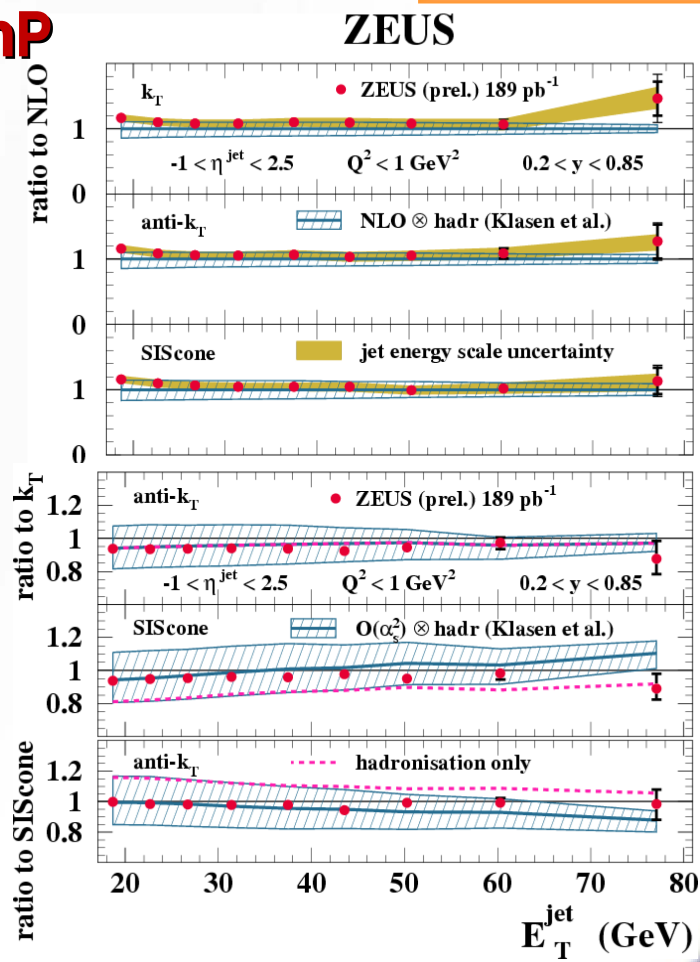
Anti-k_T and SIScone jet algorithms

Reanalysis of inclusive jets in DIS and PhP

ZEUS-prel-10-015

Jets in PhP

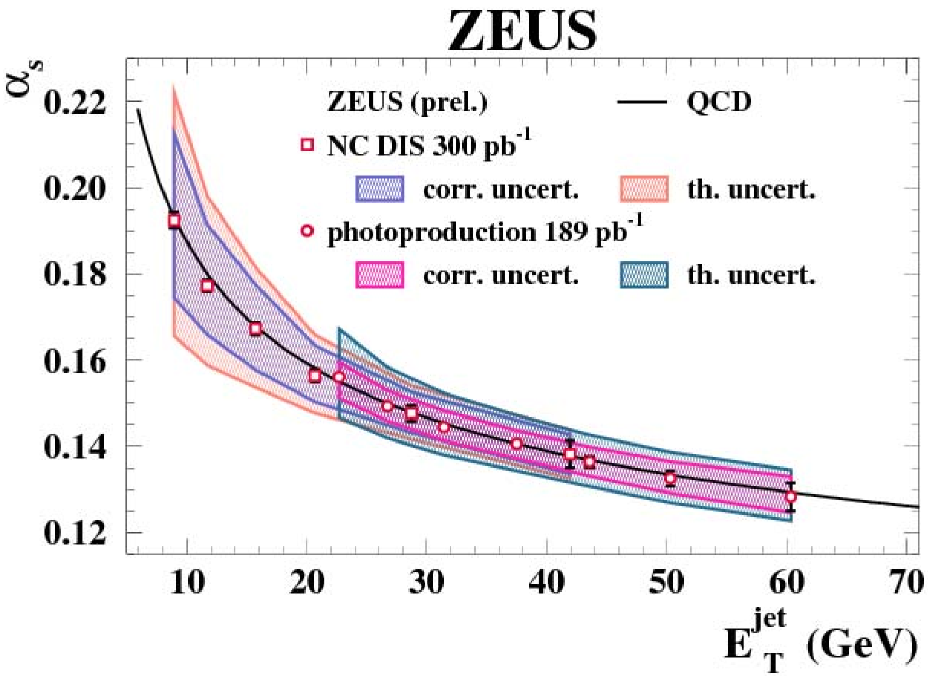


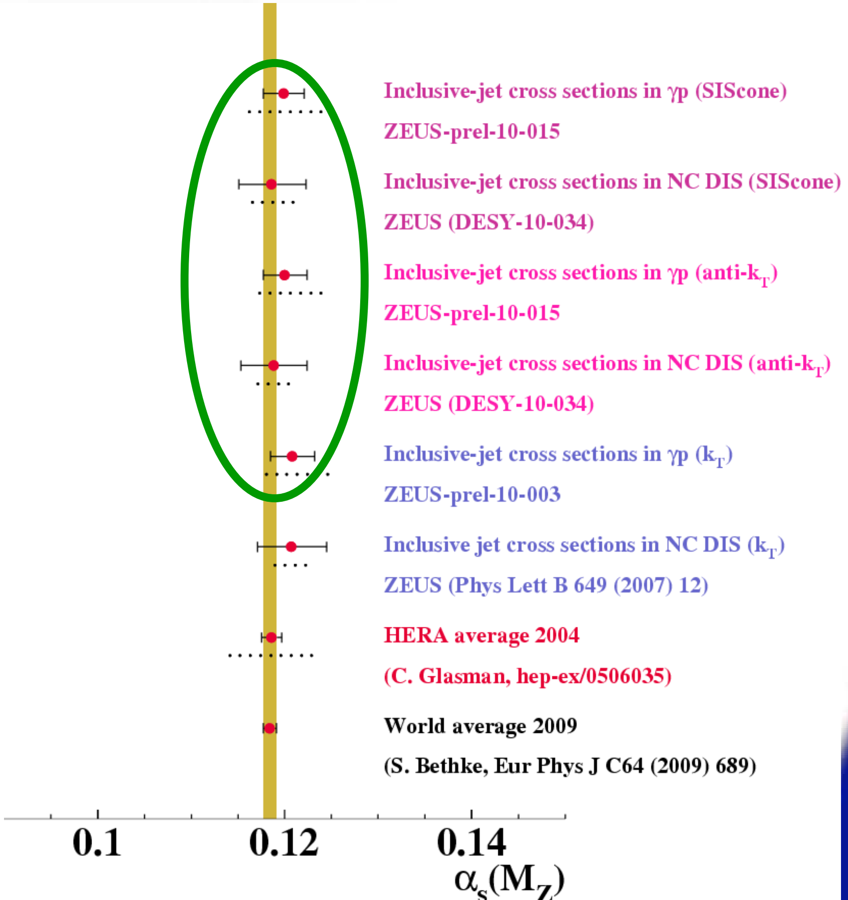


➢ **Data very well described by NLO and all the algorithms.**

α_s running from PhP to DIS

α_s extracted from the dependence of the cross section on E_T.



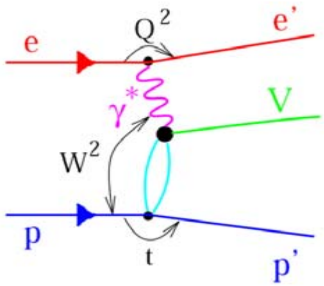


Running of the coupling constant with the scale **tested from the low to the high Q^2 regime**.

New **precise α_s measurements** from DIS and PHP in agreement with the world average.

Dipion diffractive electroproduction

Electroproduction of *V* = (*ρ(770); ρ'(1450);ρ''(1700)*) mesons and their subsequent decay into π+π- pair has been studied in 2 π invariant mass range 0.4 < $M_{\pi\pi}$ < 2.4 GeV



ρ, ρ', ρ''

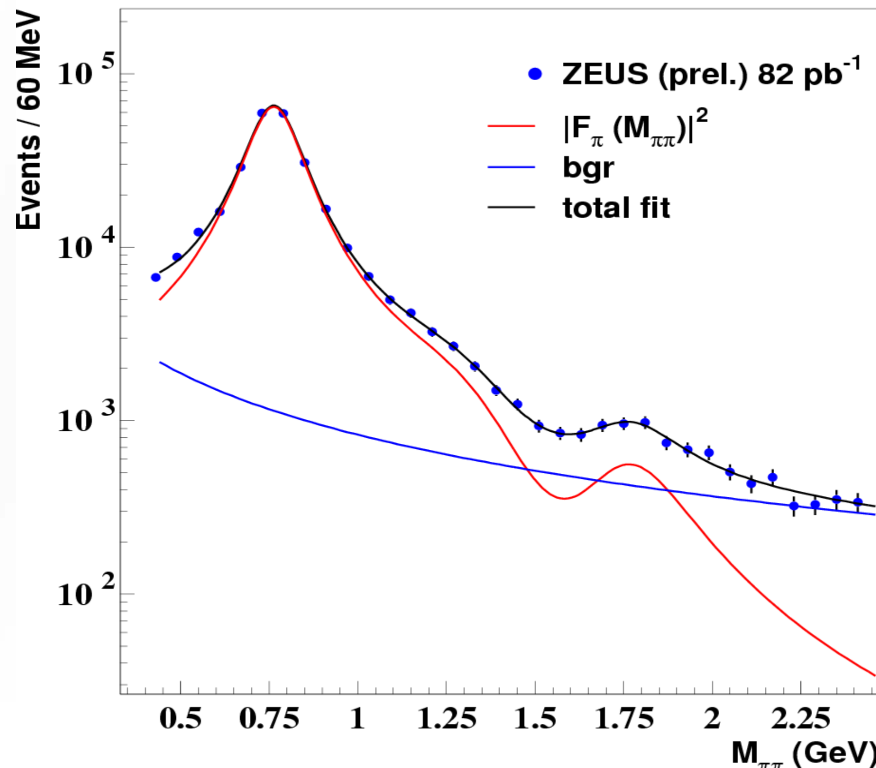
Pion electromagnetic form factor

$$\frac{dN(M_{\pi\pi})}{dM_{\pi\pi}} = N\left[|F_\pi(M_{\pi\pi})|^2 + \frac{B}{M^n_{\pi\pi}}\right]$$

$$F_\pi(M_{\pi\pi}) = \frac{BW(\rho)+\beta BW(\rho')+\gamma BW(\rho'')}{1+\beta+\gamma}$$

Parameter	ZEUS (prel.)	PDG
M_ρ	$772 \pm 2^{+2}_{-1}$	775.49±0.34
Γ_ρ	$155 \pm 5 \pm 2$	149.4±1
β	$-0.27 \pm 0.02 \pm 0.02$	
$M_{\rho'}$	$1360 \pm 20^{+20}_{-30}$	1465±25
$\Gamma_{\rho'}$	$460 \pm 30^{+40}_{-45}$	400±60
γ	$0.10 \pm 0.02^{+0.02}_{-0.01}$	
$M_{\rho''}$	$1770 \pm 20^{+15}_{-20}$	1720±20
$\Gamma_{\rho''}$	$310 \pm 30^{+25}_{-35}$	250±100

HERA I, L= 82 pb^{-1}



Q² dependence of all parameters were measured

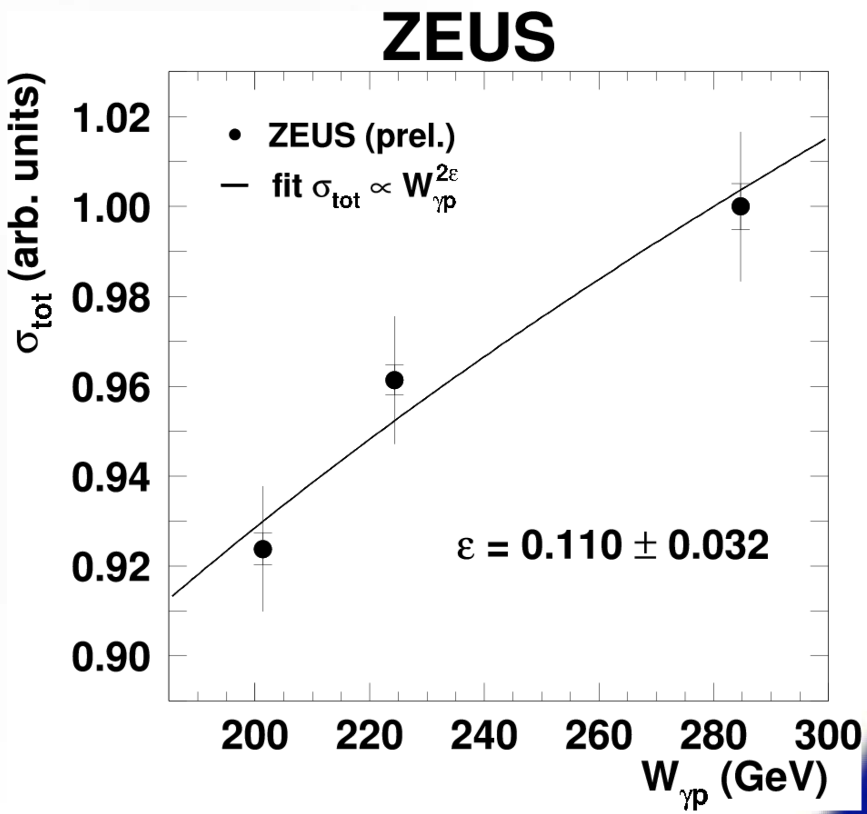
Data well described by pion form factor including interference term

Energy dependence of σ_{TOT} (γp)

The energy dependence of the total photon-proton cross-section is determined using data of three different proton beam energies→

Photon-proton center-of-mass energies $W_{\gamma p}$ = 201 GeV, 224 GeV and 285 GeV

- Normalized so to σ_{tot}(HER)=1
- Inner error bars:
  #sigtot events statistical
- Outer error bars:
  all uncert. (B-H subtraction, flux measurement, lumi)



- Model for energy dependence:
  Donnachie-Landshoff
  $\sigma_{tot} = C\, W^{2\varepsilon} + B\, W^{-2\eta}$ ($W = W_{\gamma p}$)
  At high $W_{\gamma p}$ *second term is negligible*

Totally independent of low $W_{\gamma p}$ dependence, measurements

Conclusion

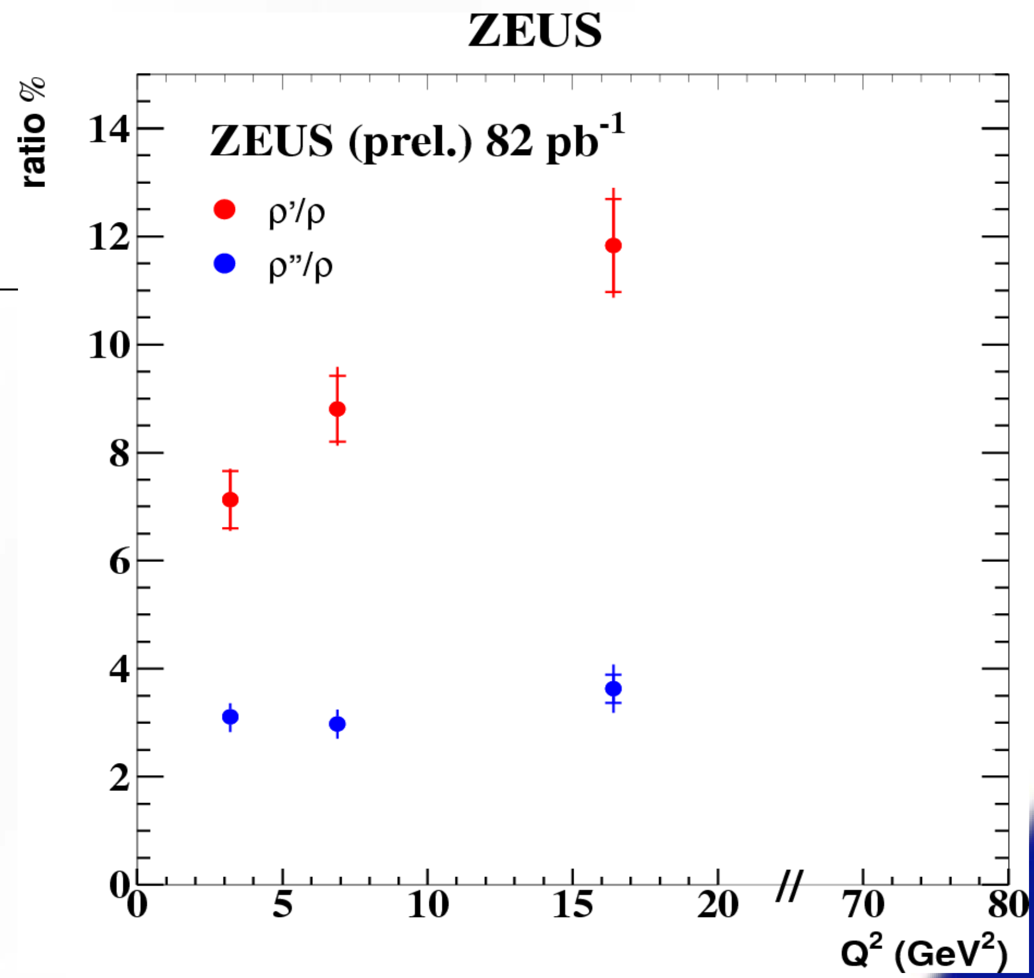
- ZEUS is a lively collaboration:
- Publishing papers
- Many new preliminary results
- New ZEUS+H1 combination measurements are providing precision data used as input in QCD fits.
- The analyses of the HERAII on NC, CC, jets and heavy flavour processes are extended to the full data statistics allowing improved precision of the results.
- The new inclusive, jets and heavy flavour data are now investigated in the context of QCD fits, allowing more stringent test on the fit formalism.

Extra slides

Dipion production

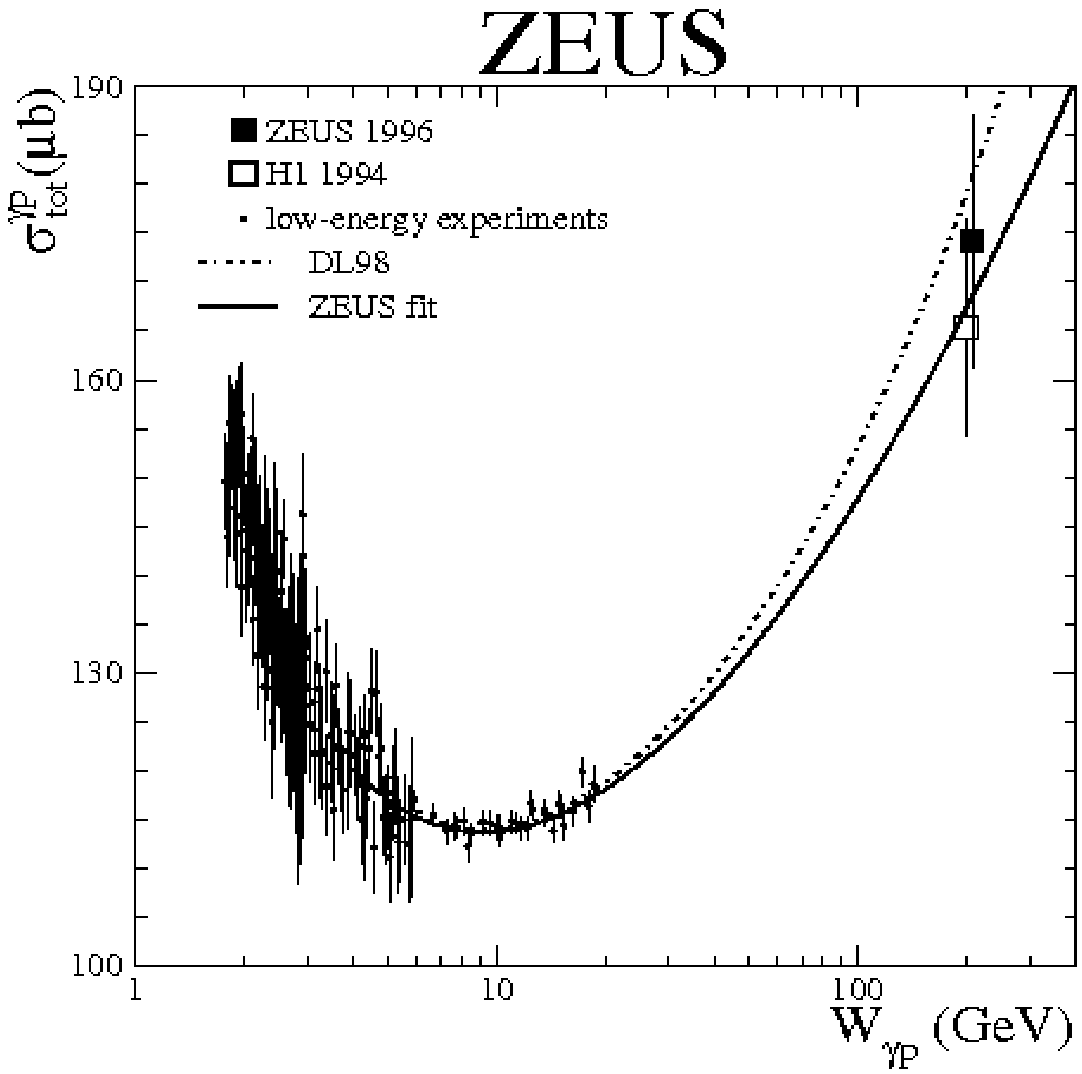
ZEUS-prel-10-012

$$R' = \sigma(\rho') \cdot Br(\rho' \to \pi\pi)/\sigma(\rho)$$



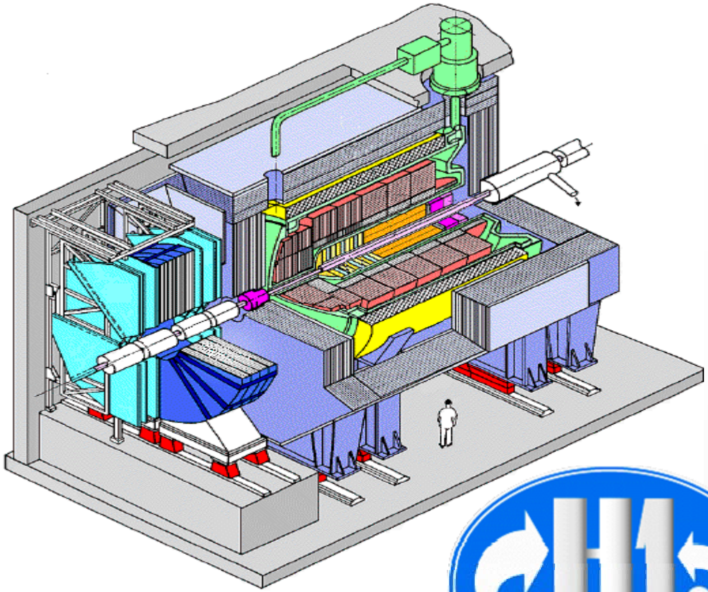
- ρ'/ρ **increases** with Q^2
- ρ''/ρ **constant** with Q^2

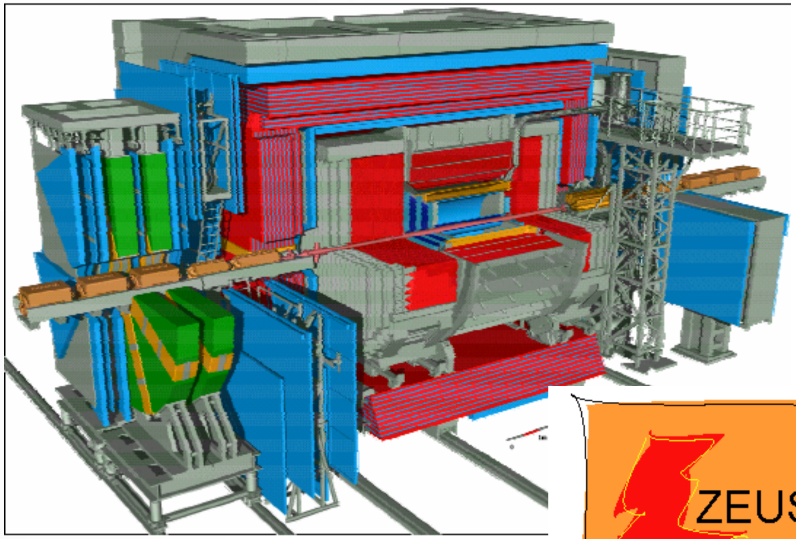
The anomalous behavior of V'(2S)/V(1S) production ratio with Q^2 was predicted in works of J. Nemchik, B. Kopeliovich, N. Nikolaev, B. Zakharov (hep-ph/9605208)



ZEUS
ZEUS 1996
H1 1994
low-energy experiments
DL98
ZEUS fit
190
160
130
100
1
10
100
$\sigma_{tot}^{\gamma p}$ (μb)
$W_{\gamma p}$ (GeV)

H1 & ZEUS: Hermetic multi-purpose detectors





Liquid Argon Calorimeter

optimized for precision measurement of the scattered lepton

$\sigma_E/E = 11\%/\sqrt{E}$ **(ele)**

$\sigma_E/E = 50\%/\sqrt{E}$ **(had)**

Uranium-scintillator Calorimeter

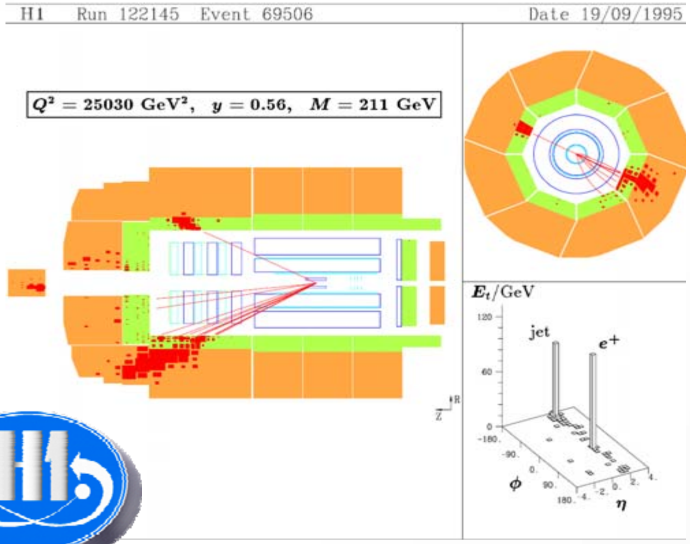
optimized for precision measurement of the hadronic final state

$\sigma_E/E = 18\%/\sqrt{E}$ **(ele)**

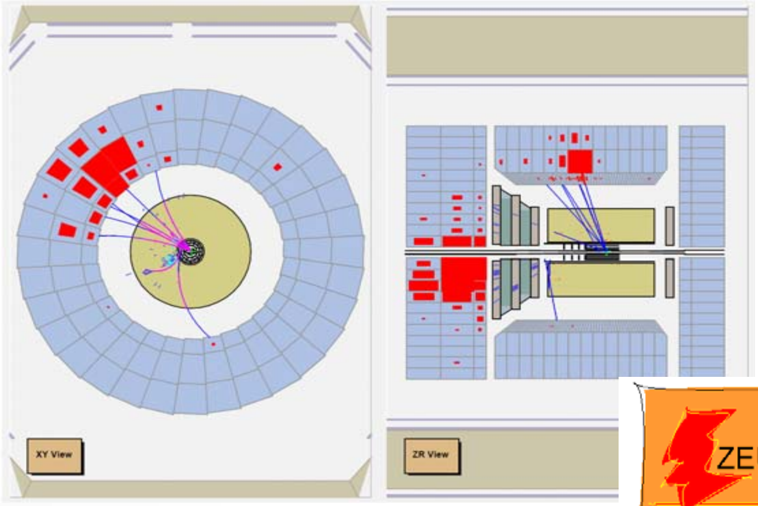
$\sigma_E/E = 35\%/\sqrt{E}$ **(had)**

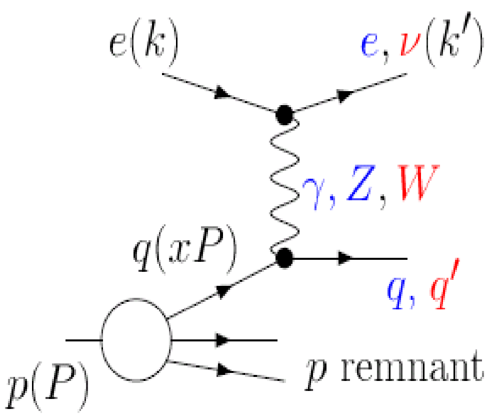
Deep Inelastic ep Scattering

Neutral Current



Charged Current





$$Q^2 = -(k - k')^2$$

$$x = \frac{Q^2}{2P \cdot (k - k')}$$

$$y = \frac{P \cdot (k - k')}{P \cdot k}$$

Q^2 = -(4-momentum of propagator)^2 – the virtuality of the exchanged boson.

x – fractional momentum of proton carried by struck quark q

y – fractional energy of the incoming lepton transferred to the proton in the proton's rest frame (inelasticity)

Deep Inelastic ep Scattering

NC: Sensitive to gluons, valence quarks and see quarks

$$\frac{d^2\sigma^{\pm}_{NC}}{dxdQ^2} \approx \frac{2\alpha\pi^2}{xQ^4}\left[Y_+ F_2 \mp Y_- xF_3 - y^2 F_L\right] \qquad Y_\pm = \tfrac{1}{2}(1 \pm (1-y^2))$$

$$\boxed{F_2 \propto \sum_i e_i^2 (xq_i + x\bar{q}_i)}$$

All quarks at LO.
Gluon from scaling violations.

$$\boxed{xF_3 \propto \sum_i xq_i - x\bar{q}_i}$$

Valence quarks

$$\boxed{F_L \propto \alpha_s xg}$$

Gluon at NLO

Use 'reduced cross section'
to remove kinematic dependence:

$$\boxed{\sigma_r = \frac{xQ^2}{2\alpha\pi^2 Y_+} \frac{d^2\sigma^{\pm}_{NC}}{dxdQ^2} \approx F_2}$$

CC: Flavour decomposition

e-p: $$\frac{d^2\sigma^{-}_{CC}}{dxdQ^2} = \frac{G_F^2}{2\pi}\left(\frac{M_W^2}{M_W^2 + Q^2}\right)\left[u + c + (1-y)^2(\bar{d} + \bar{s})\right]$$

e+p: $$\frac{d^2\sigma^{+}_{CC}}{dxdQ^2} = \frac{G_F^2}{2\pi}\left(\frac{M_W^2}{M_W^2 + Q^2}\right)\left[\bar{u} + \bar{c} + (1-y)^2(d + s)\right]$$

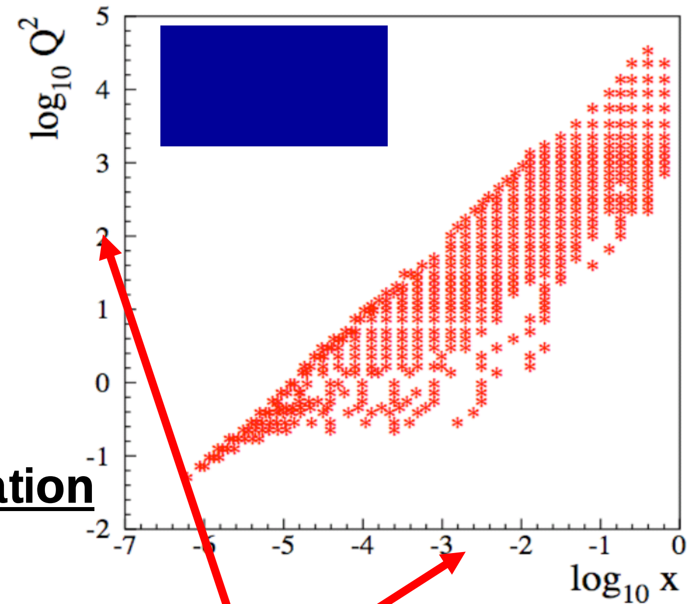
Inclusive cross section combination

- H1 & ZEUS have combined inclusive DIS cross sections from HERA I data => New average with **L=240 pb^{-1}**

- **Combination procedure:**

1) Swim all point to a common **Q^2-x grid**
2) Move 820 GeV data to 920 GeV p-beam energy (not for NC at y>0.35)
3) Calculate average values and uncertainties
4) Evaluate "procedural uncertainties"

- $\chi 2$ minimalisation method for data combination



1402 data points combined to **741 cross section** measurements:

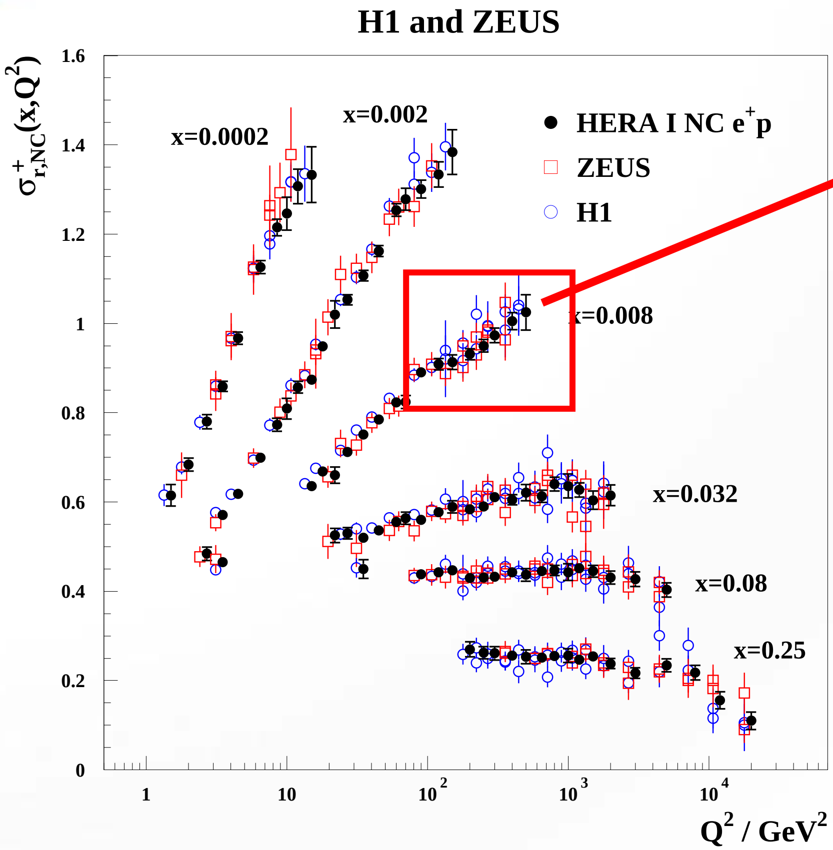
- **110** correlated syst. error sources (H1 & ZEUS)

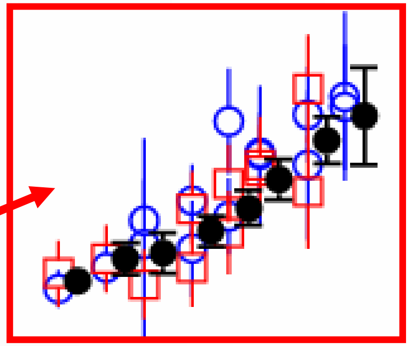
- **3** procedural uncertainties

-H1 & ZEUS syst. assumed independent (except 0.5% lumi normalisation)

Span **6 orders of magnitude** in x and Q^2

Combined H1 & ZEUS data





- Unprecedented precision due to cross calibration of detectors

- Data show good consistency

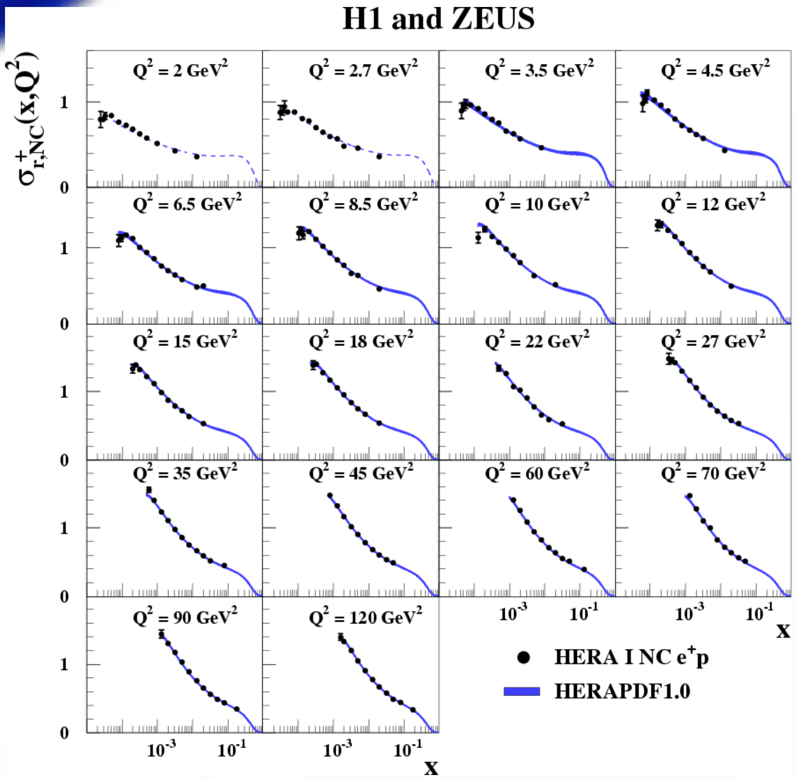
$\chi 2/n_{dof}$ = 637/656

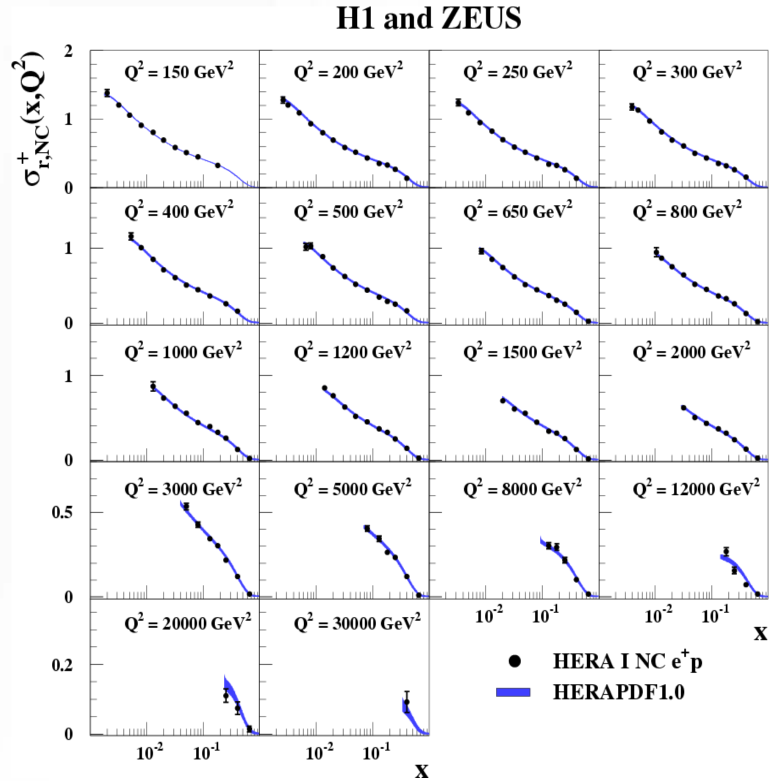
- Precision:
  2% for $3<Q^2<500$ GeV^2
  1% for $20< Q^2<100$ GeV^2

Combination of H1 & ZEUS HERA I data provides a model independent tool to study consistency of the data and to reduce systematic error!

F2 with combined e+p NC

Low/medium Q^2 bins (2-150 GeV^2) **High Q^2 bins(150-30000 GeV^2)**



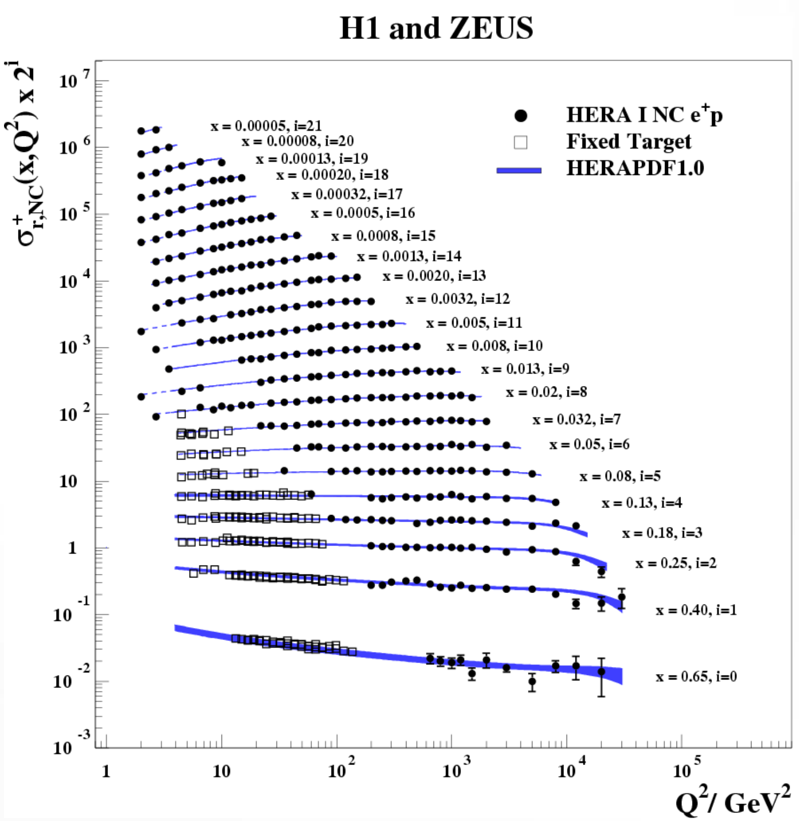


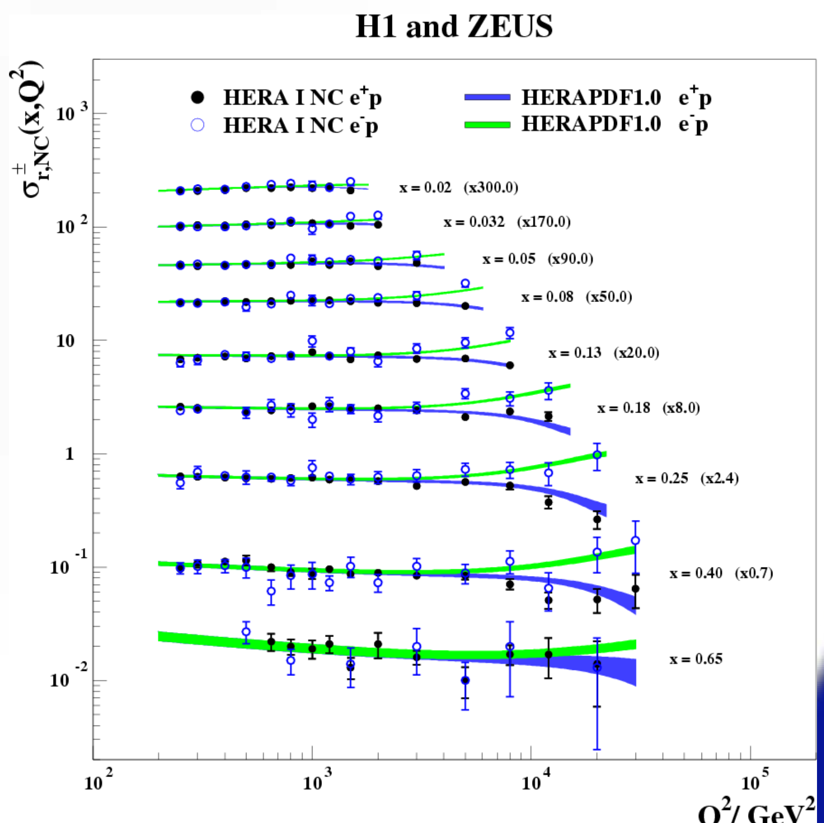
- F_2 (x,Q^2) shows strong rise as x->0, the rise increases with increasing Q^2
- Data well described by QCD fit from Q^2=2 to 30000 GeV^2

HERA combined NC data

- Data show strong **scaling violations at low x** → large gluon density

- NC data at high-Q2:
Zγ interference **destructive (e+p)** and **constructive (e-p)**





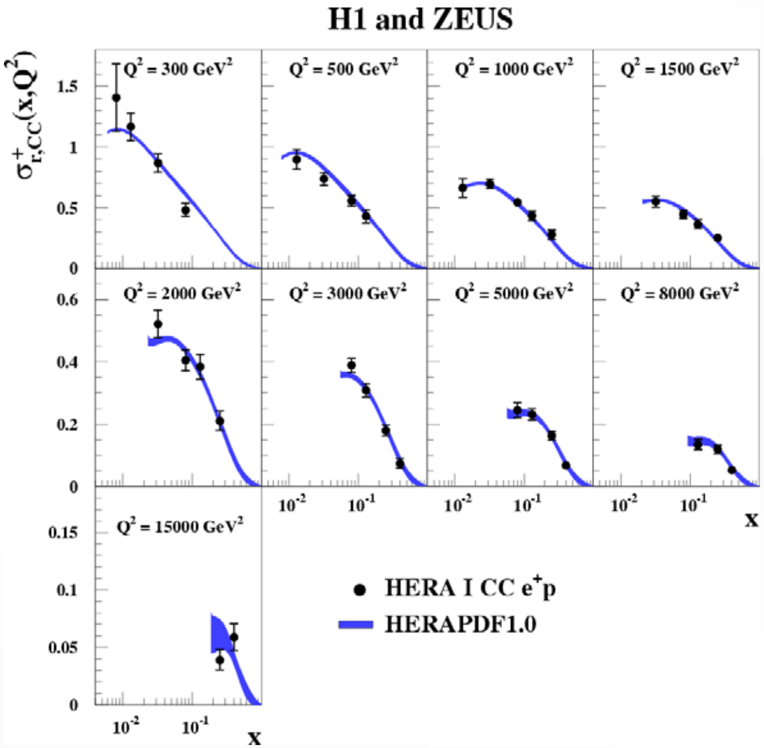
Good agreement between data and NLO QCD fit!

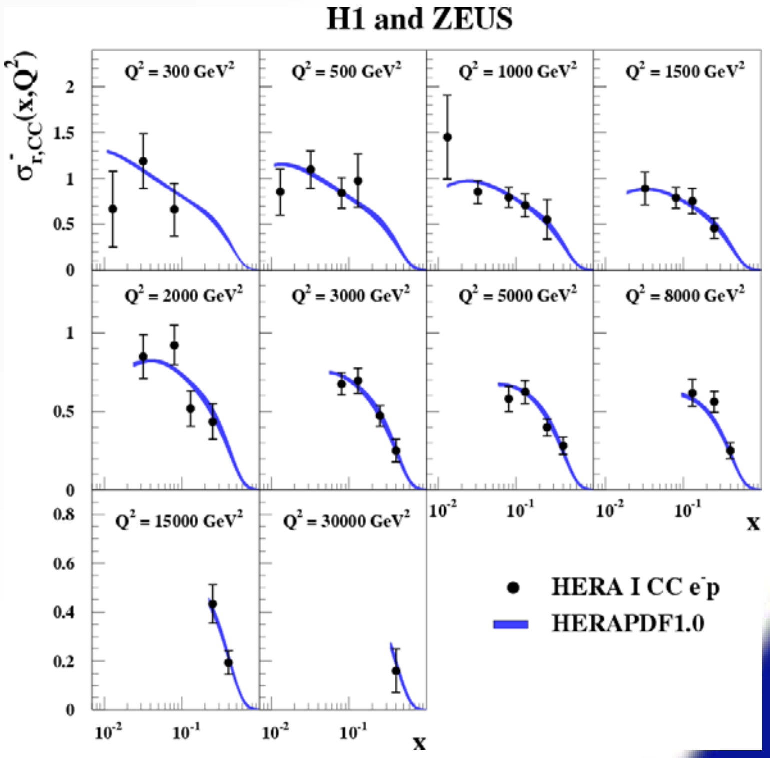
HERA combined CC data

- CC e^+p / e^-p allows to disentangle contributions of d and u quarks
- Probes flavor structure of the proton

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

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





- e^+p most sensitive to $d(x,Q^2)$
- $e+p$ valence quarks suppressed by factor $(1-y)^2$

- e^-p most sensitive to $u(x,Q^2)$

HERA-I QCD fit - HERAPDF1.0

- Fit uses **combined H1&ZEUS NC, CC data only**
- DGLAP equations at **NLO in MSbar scheme**
- Parameterize parton distribution functions at starting scale and evolve with Q^2.
- **Thorne-Roberts Variable Flavour Number Scheme** (as for MSTW08):
  →takes the quark masses into account

Scheme	TRVFNS
Evolution	QCDNUM17.02
Order	NLO
Q_0^2	1.9 GeV^2
$f_s = s/D$	0.31
Renorm. scale	Q^2
Factor. scale	Q^2
Q^2_{min}	3.5 GeV^2
$\alpha_S(M_Z)$	0.1176
M_c	1.4 GeV
M_b	4.75 GeV

PDFs at the starting scale parameterised as:

$$xf(x,Q_0^2) = Ax^B(1-x)^C(1+Dx+Ex^2)$$

where xf = xu_{val}, xd_{val}, xg, xUbar, xDbar

PDF	A	B	C	D	E
xg	sum rule	FIT	FIT	-	-
xu_{val}	sum rule	FIT	FIT	-	FIT
xd_{val}	sum rule	$=B_{u_{val}}$	FIT	-	-
$x\overline{U}$	$\lim_{x\to 0}\overline{u}/\overline{d} \to 1$	FIT	FIT	-	-
$x\overline{D}$	FIT	$=B_{\overline{U}}$	FIT	-	-

Results:
10 parameters for central fit
$\chi 2/n_{dof}$ = 574/582

HERA-I QCD fit - uncertainties

- **Experimental uncertainty:**
  Take into account experimental errors including, correlations bin to bin and between experiments/datasets => $\Delta\chi^2=1$

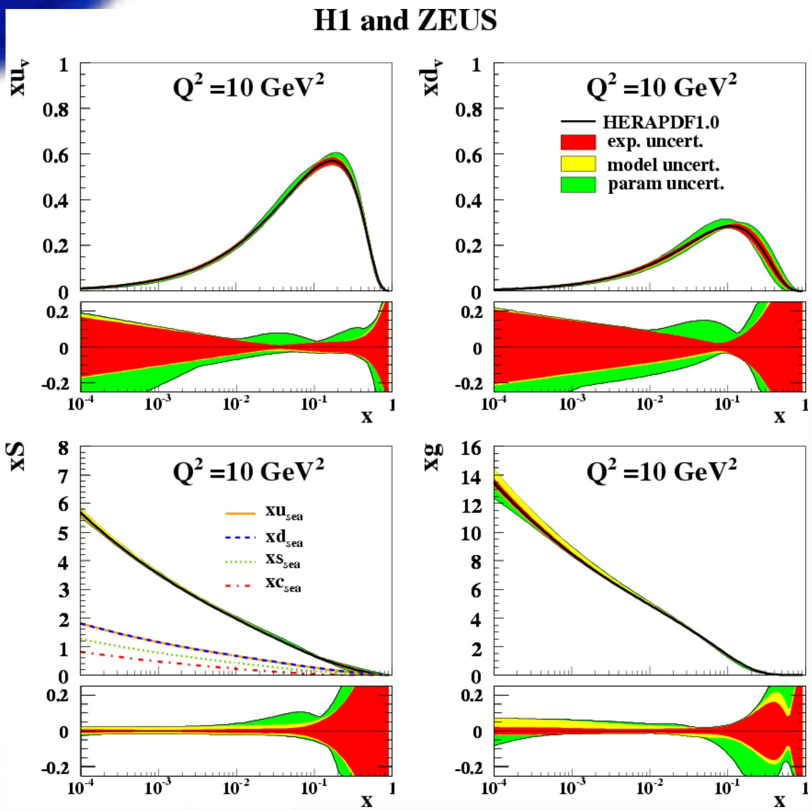
- **Model uncertainty includes theoretical errors:**

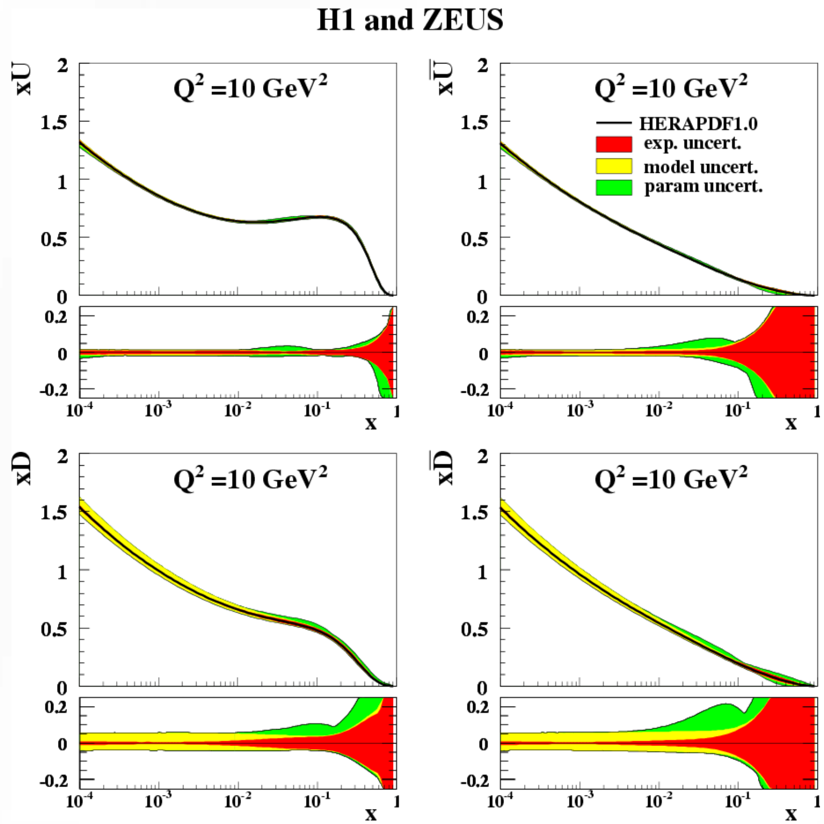
Variation	Standard Value	Lower Limit	Upper Limit
f_s	0.31	0.23	0.38
m_c [GeV]	1.4	$1.35^{(a)}$	1.65
m_b [GeV]	4.75	4.3	5.0
Q^2_{min} [GeV^2]	3.5	2.5	5.0
Q^2_0 [GeV^2]	1.9	$1.5^{(b)}$	$2.5^{(c,d)}$

$^{(a)}Q_0^2 = 1.8$ $^{(c)}m_c = 1.6$
$^{(b)}f_s = 0.29$ $^{(d)}f_s = 0.34$

- **Parameterisation uncertainty:**
  Vary parameterisation of PDFs at starting scale by adding in extra parameters in the fit

HERAPDF1.0 at Q2=10GeV2

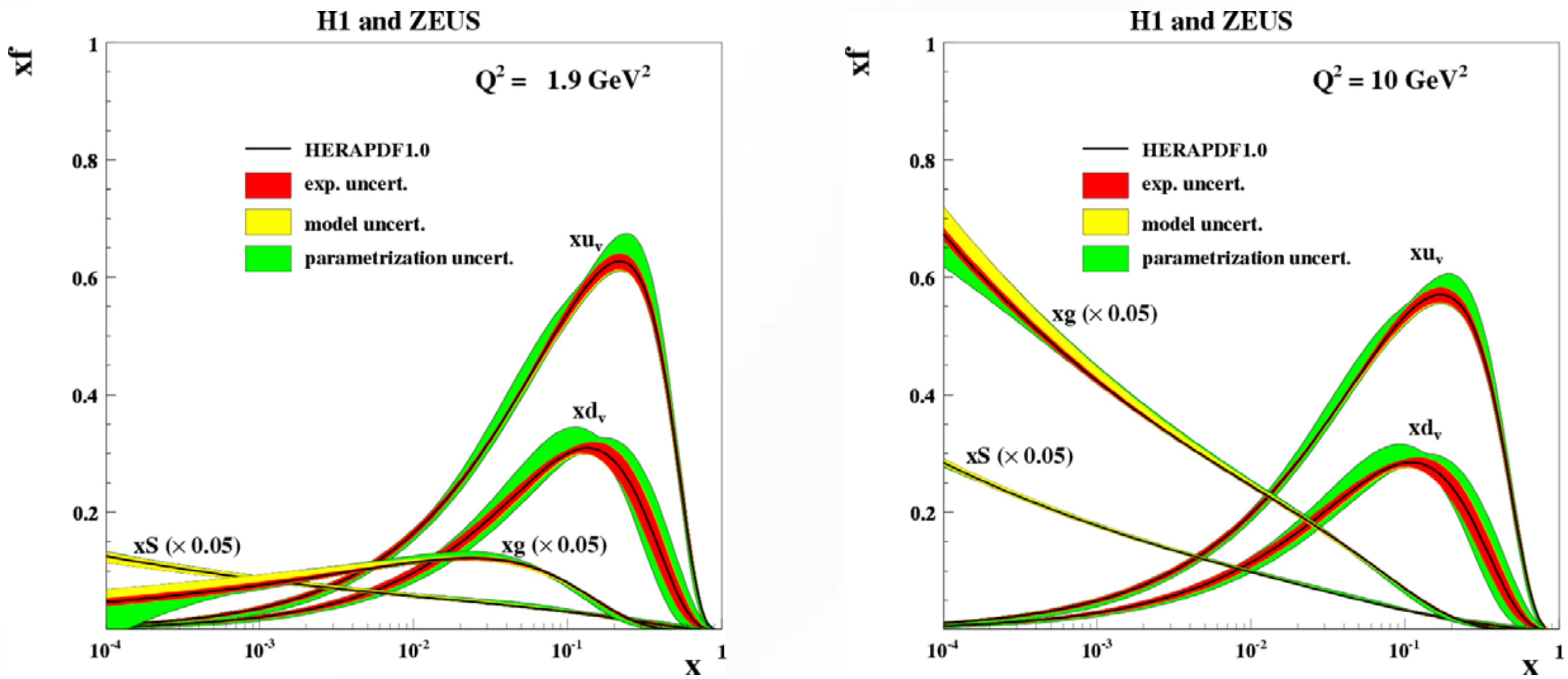




- **High precision** for sea and gluon at **low x**
- Reasonable precision for valence at high x
- Gluon error relatively large at high x

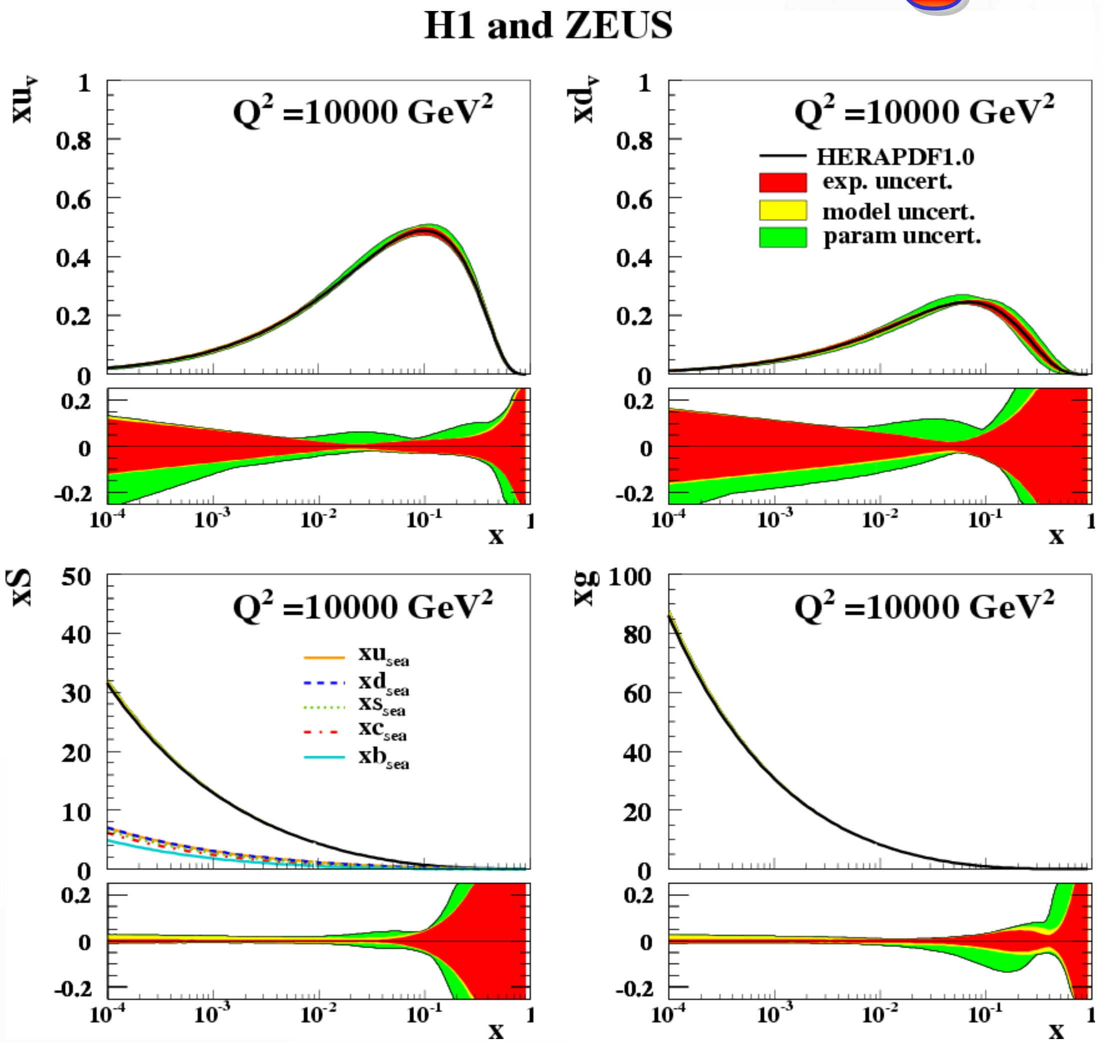
HERAPDF1.0

Distributions for valence quarks, see and gluons



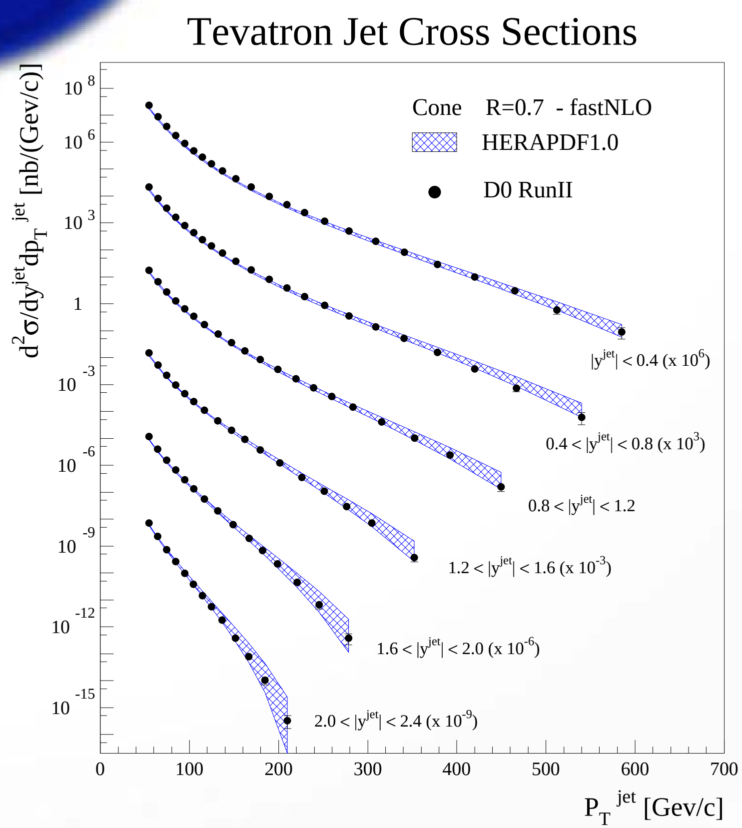
Gluon and see distributions are scaled by factor 20

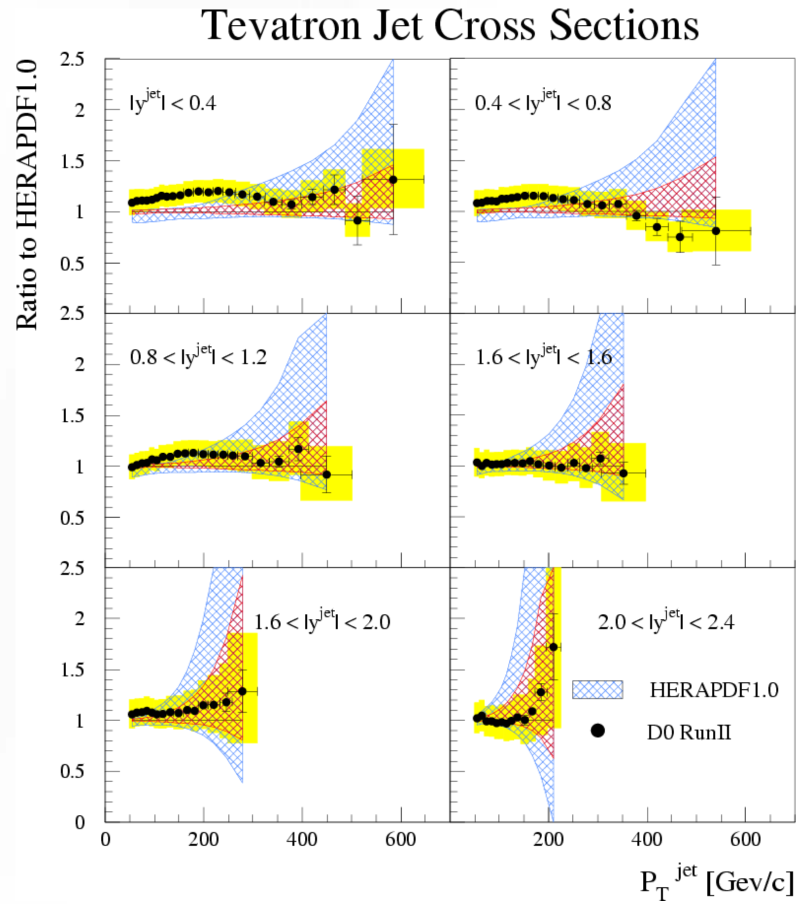
HERAPDF1.0 at high Q2



Small errors on gluon & see distributions at LHC energies enables precise predictions for LHC cross sections

HERAPDF1.0: Crosscheck with TeVatron data





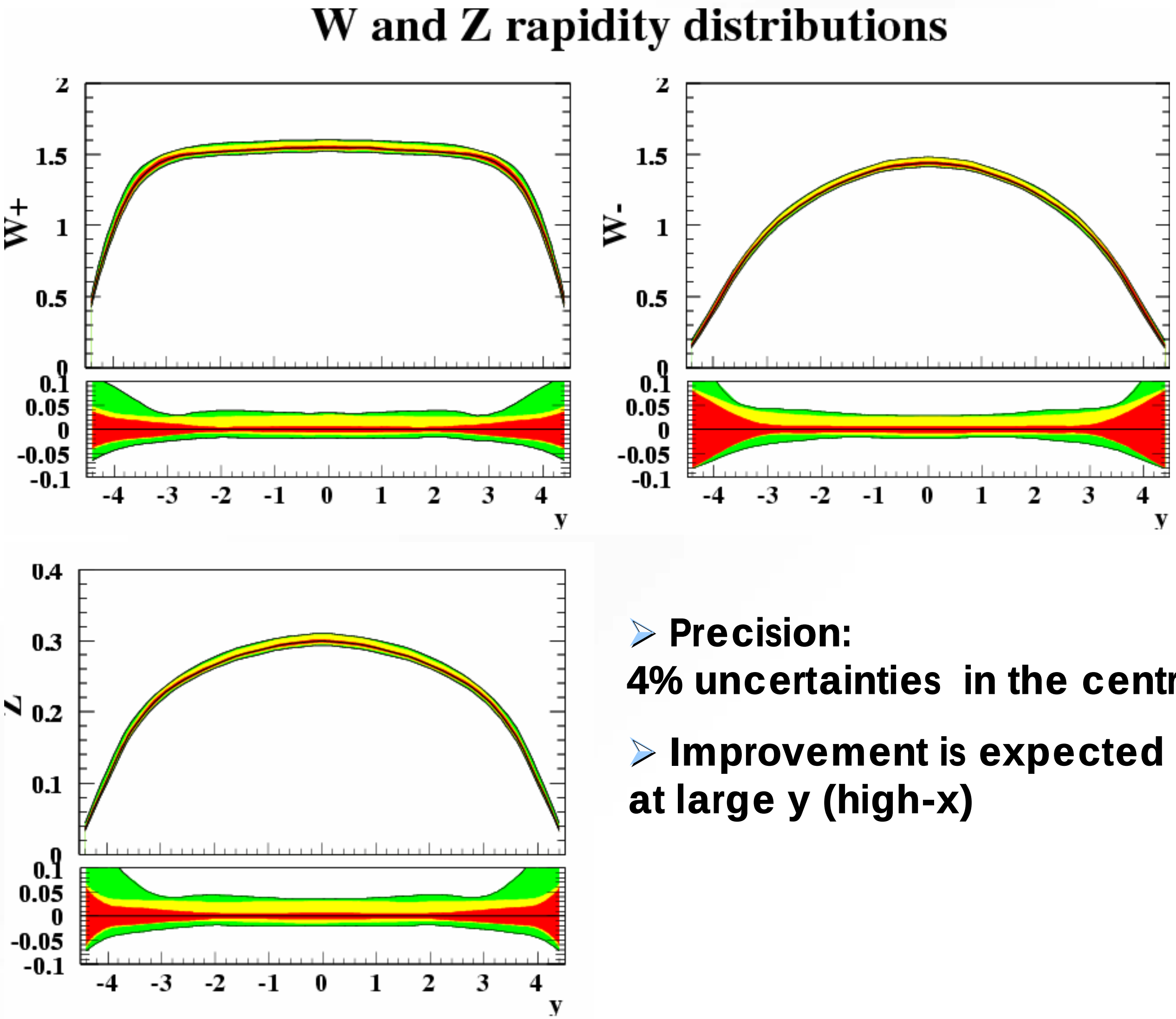
HERAPDF1.0 describes TeVatron data up to the high-Et jet production!

Ratio of D0 high Et jet cross-section to HERAPDF1.0 prediction:

- **Total PDF uncertainty blue**
- **PDF experimental red**
- **Systematic experimental error yellow**

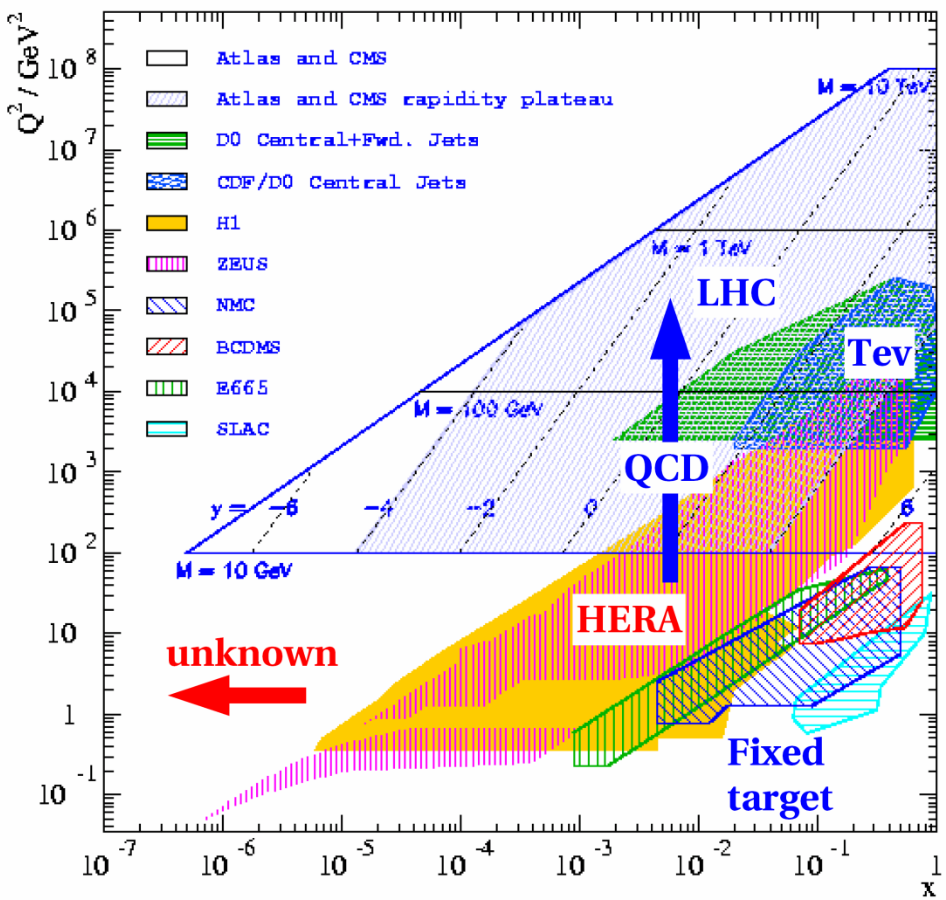
HERAPDF1.0: Impact on LHC

Predictions for the W/Z production cross sections using HERAPDF1.0 (including experimental, model and parameterisation uncertainties)



- **Precision:**
  4% uncertainties in the central rapidity range
- **Improvement is expected with HERAII data at large y (high-x)**

Kinematic plane

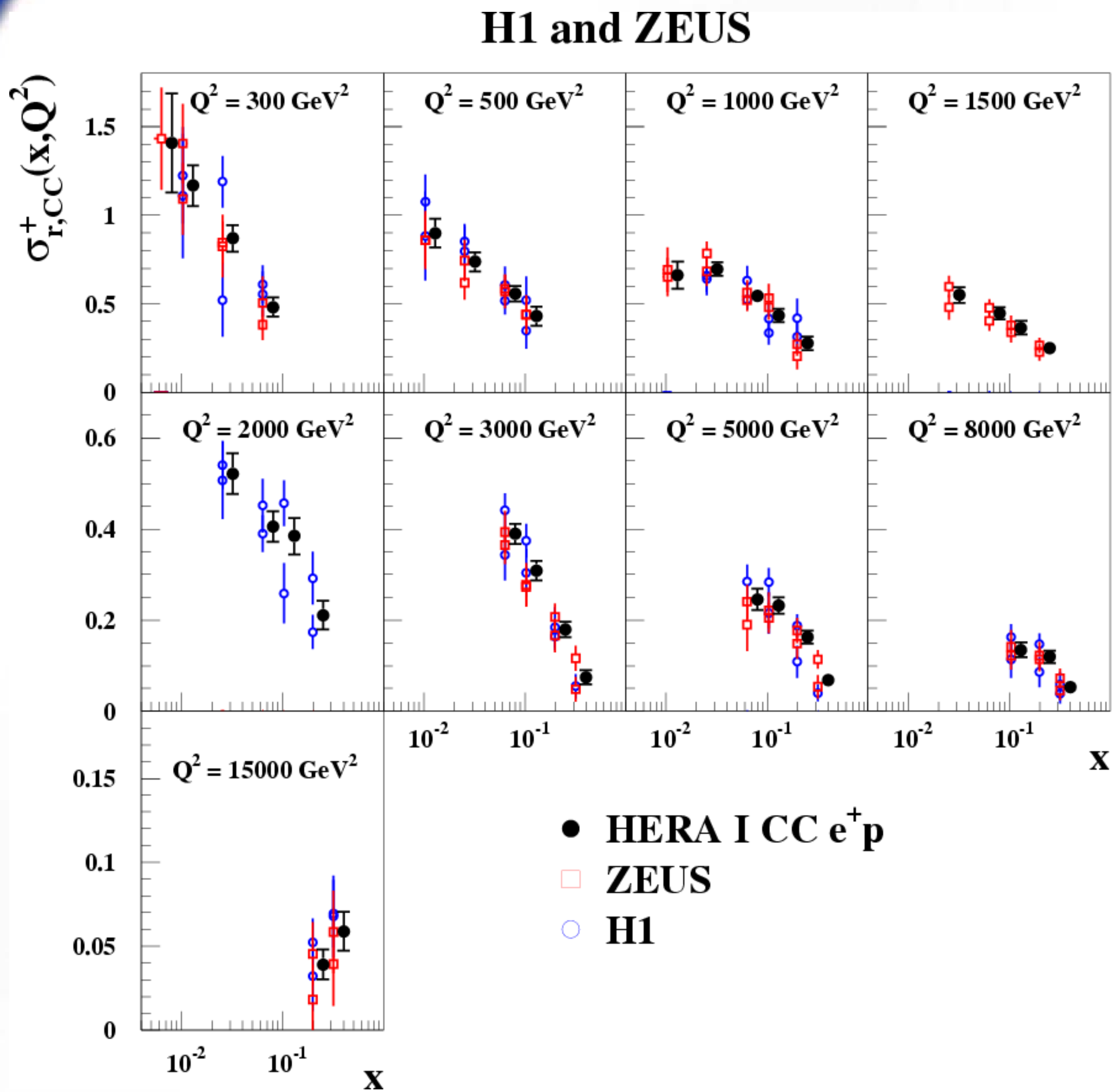


QCD evolution extrapolates HERA measured PDFs to LHC

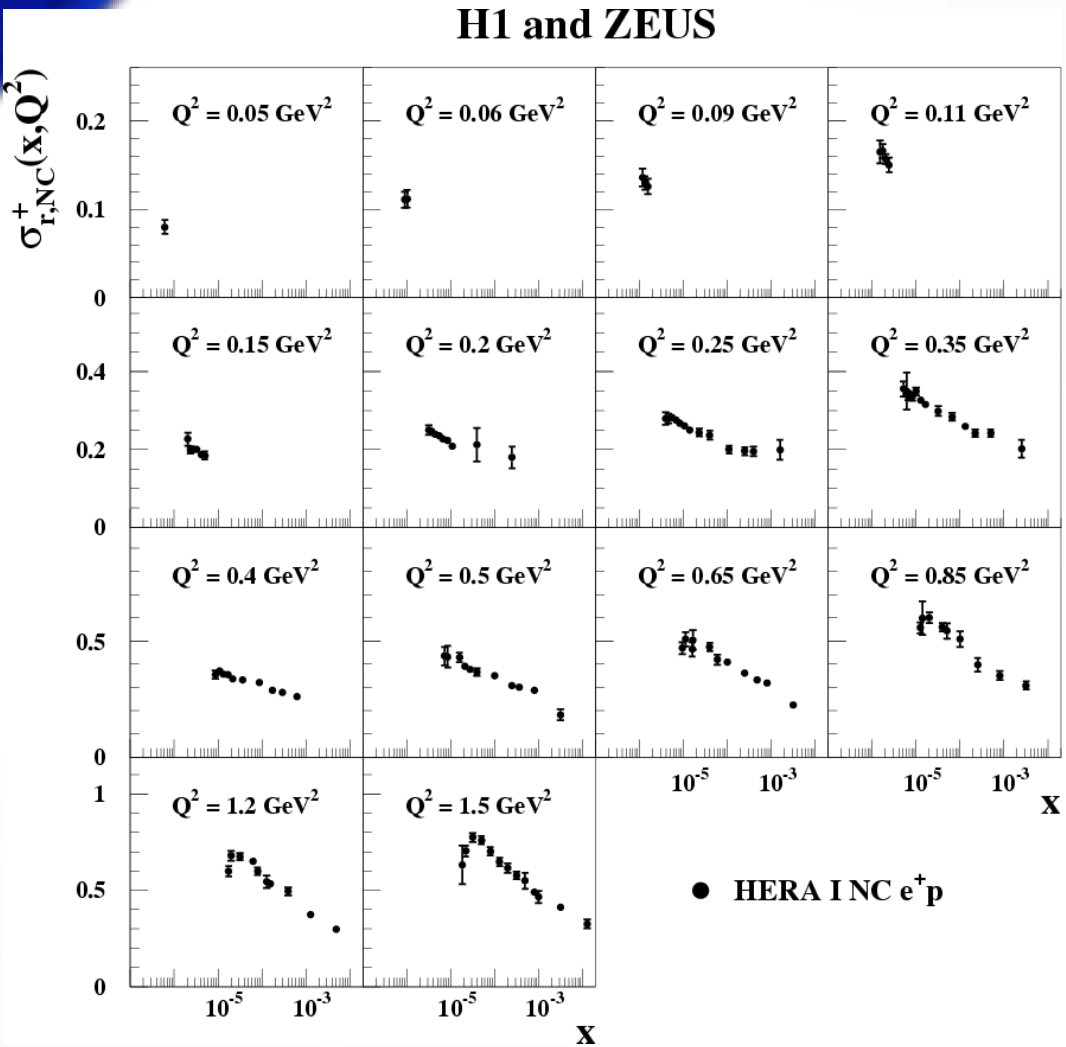
PDF's obtained in low x regime at HERA are applicable to LHC

HERA data cover LHC central rapidity range for M > 100 GeV

HERA combined CC e+p

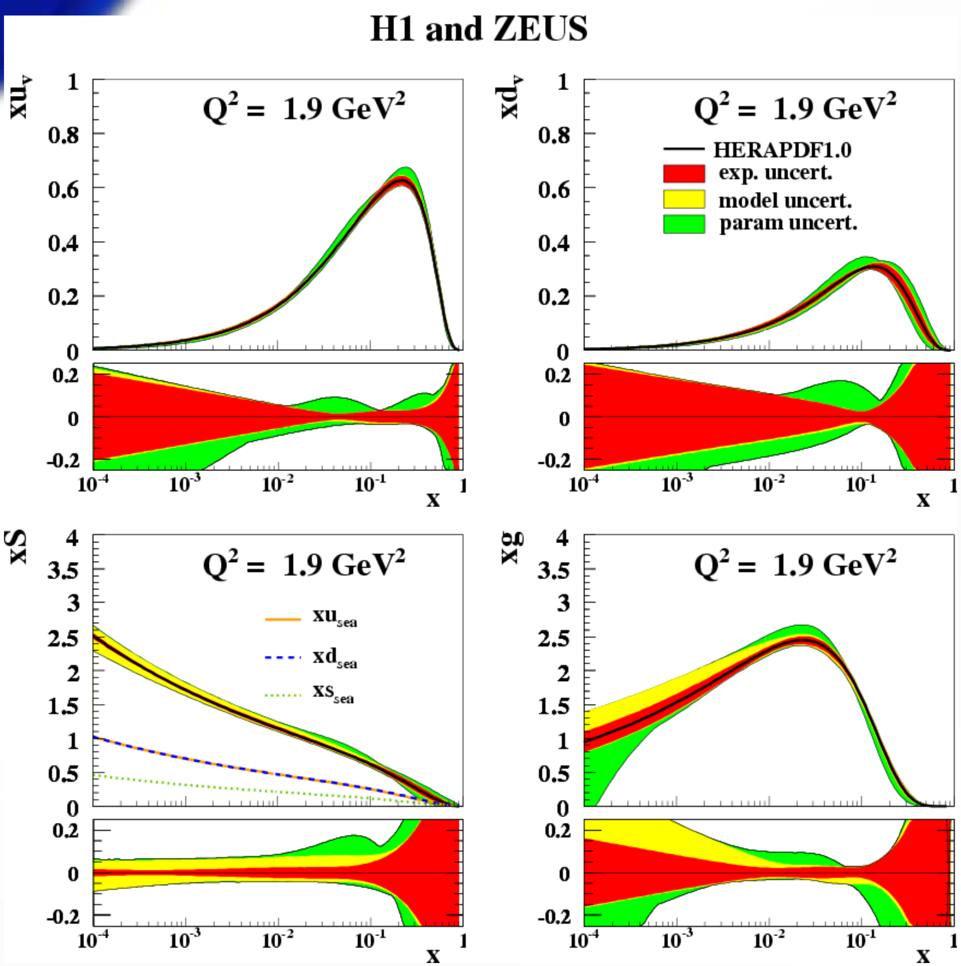


HERA combined NC e+p at very low Q2

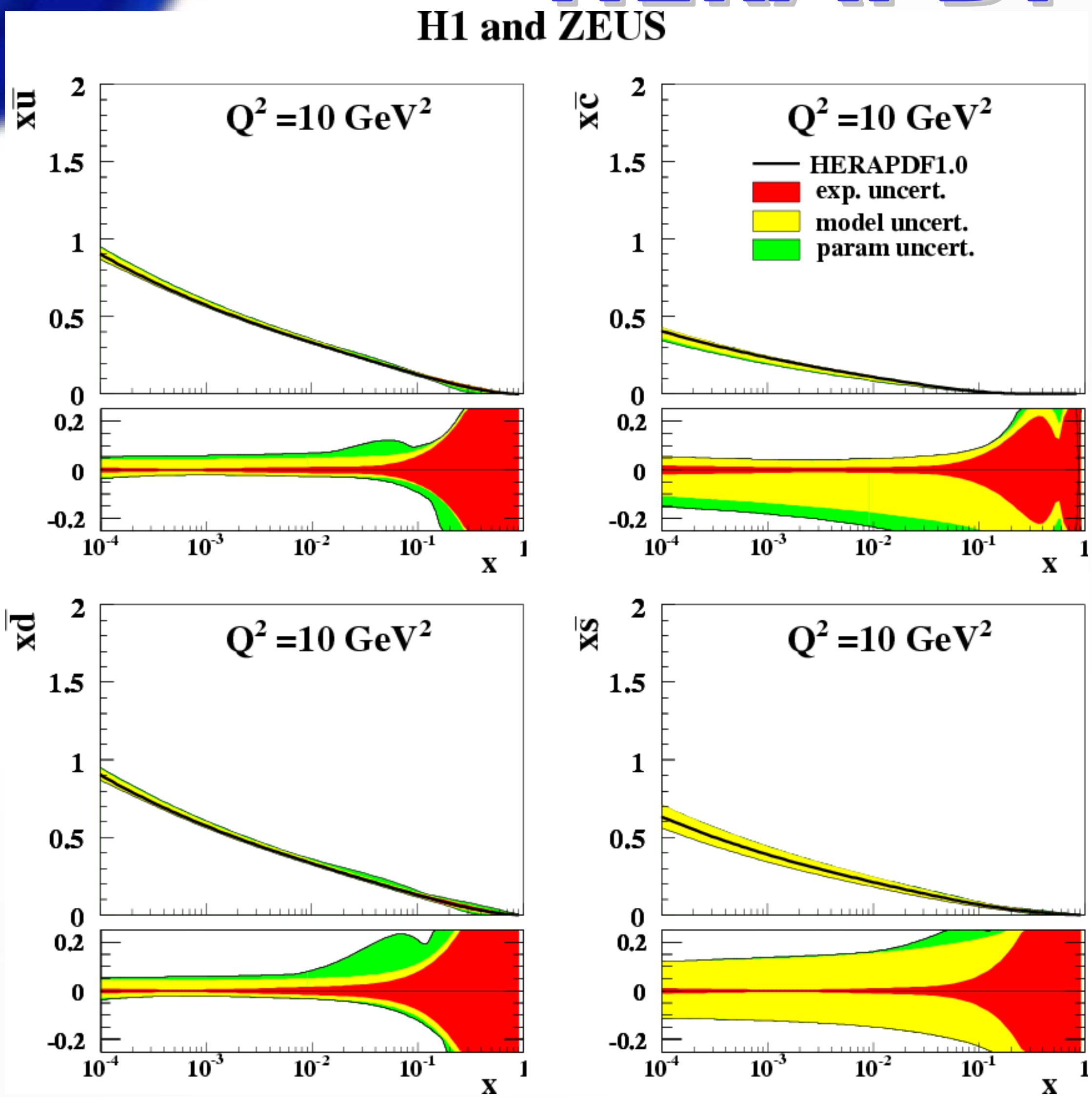


- Data shown in very low Q^2 region (0.05-1.5 GeV2)
- pQCD not expected to work in the very low Q^2 region.

PDF from HERAPDF1.0 at low Q2

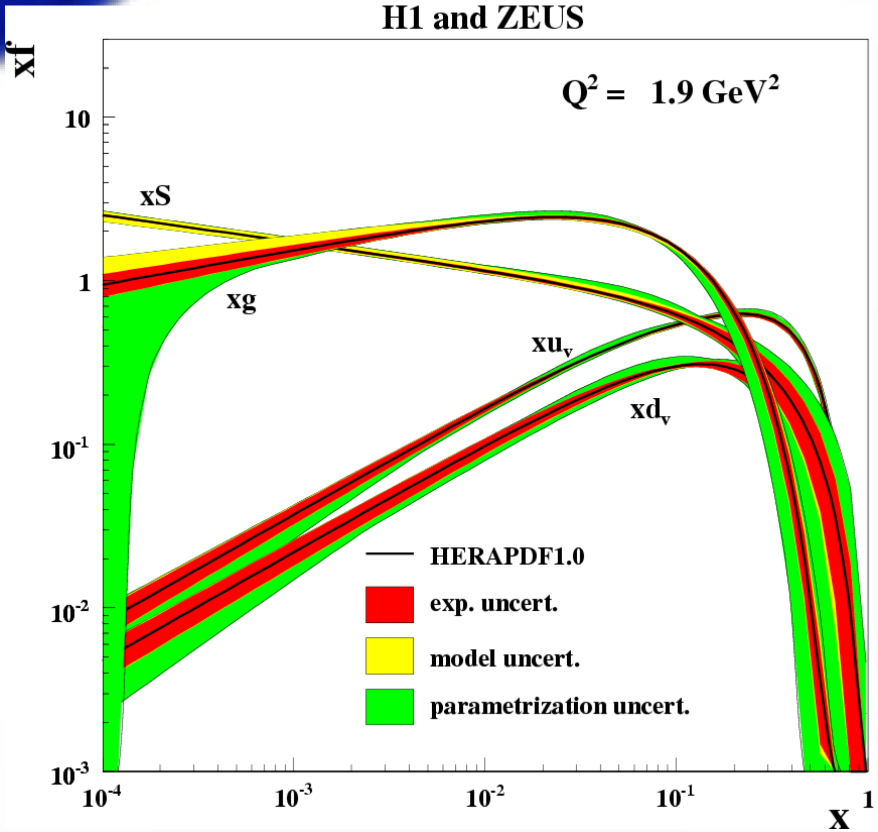


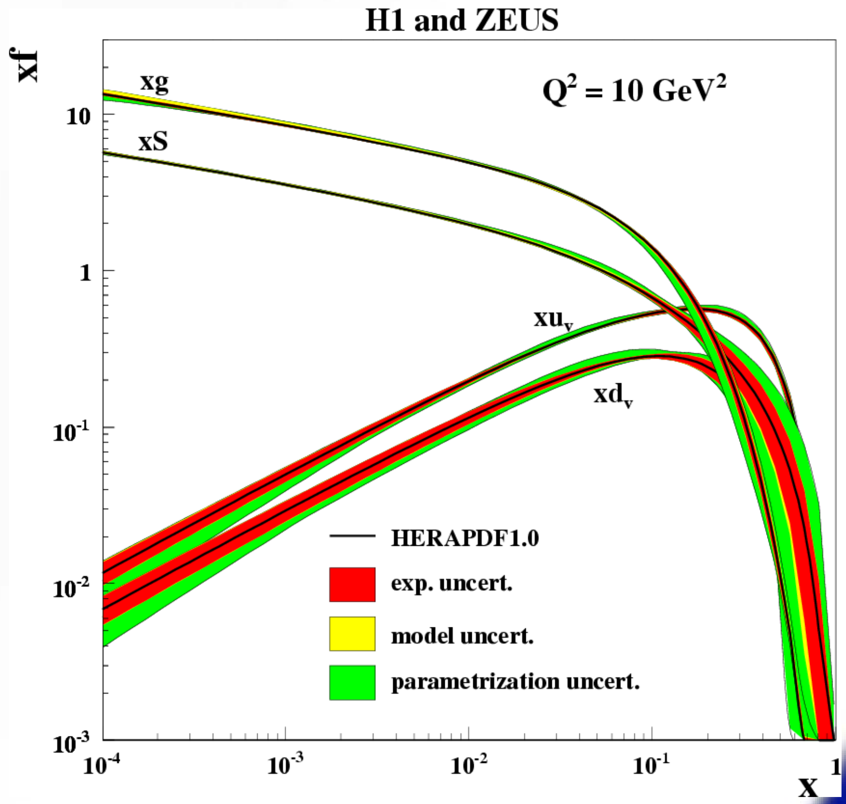
HERAPDF1.0



Parton Distribution Function xu, xd, xs and xc at Q^2 = 10 GeV^2

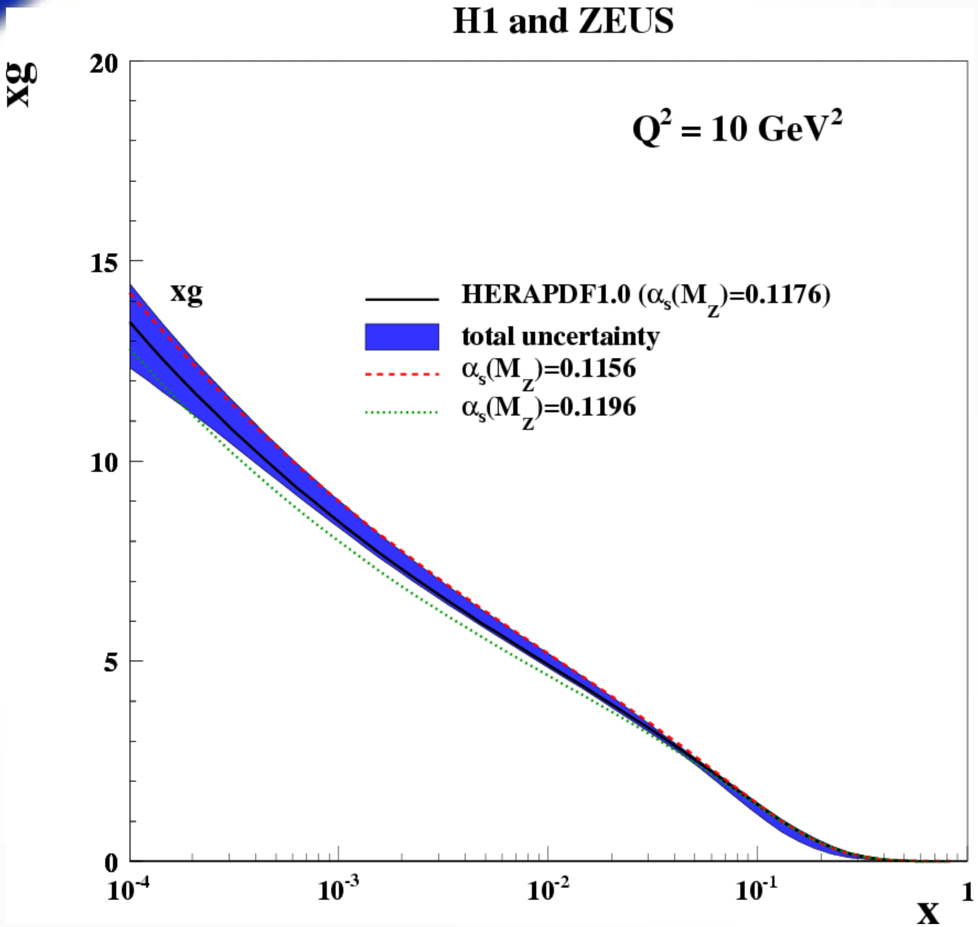
PDF from HERAPDF1.0



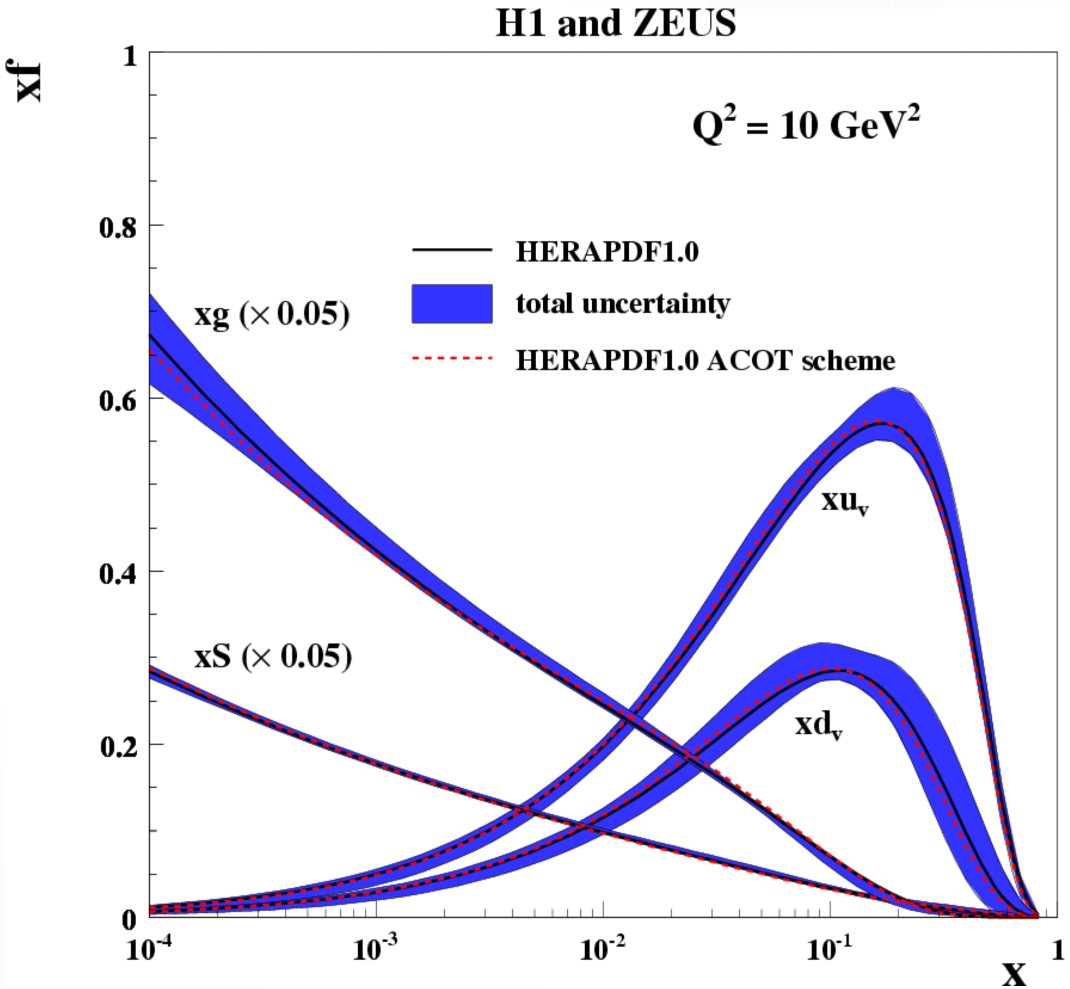


Distributions for valence quarks, see and gluons (logarithmic scale)

Gluon density vs different α_s values

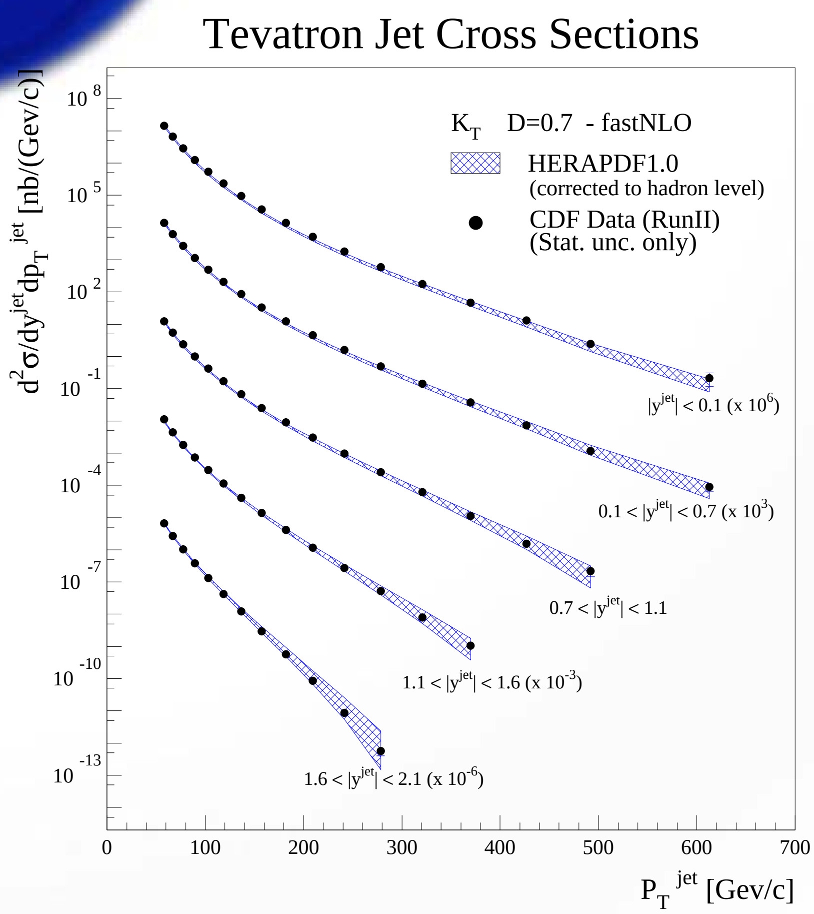


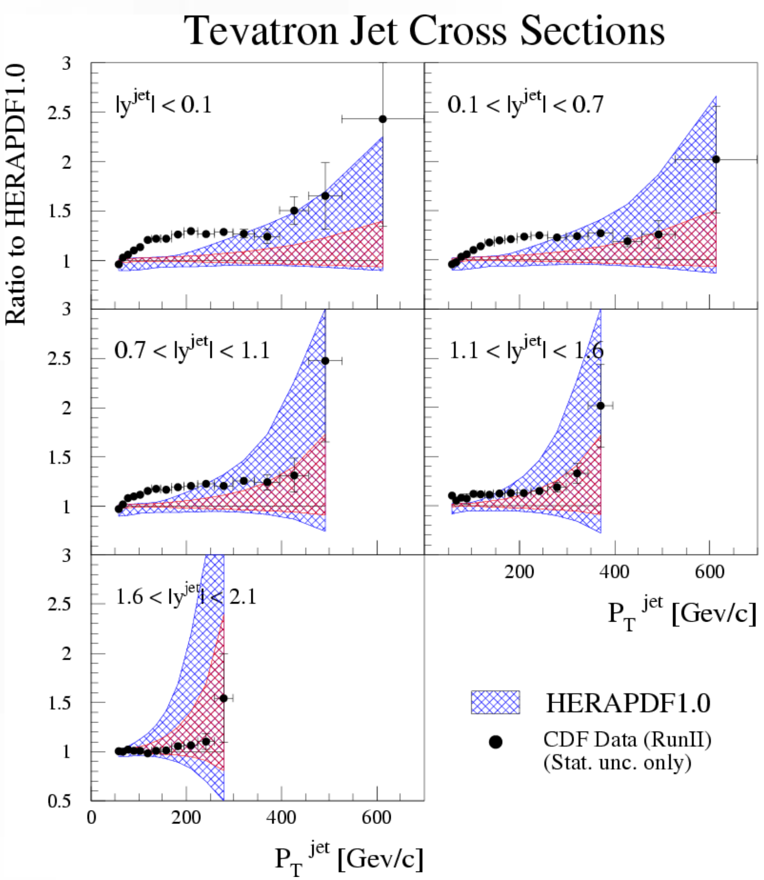
HERAPDF1.0 vs. HERAPDF1.0 ACOT scheme

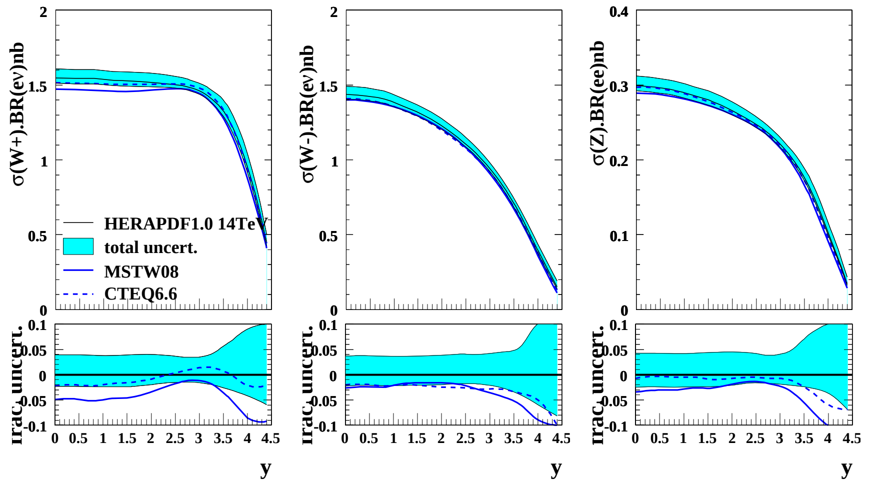


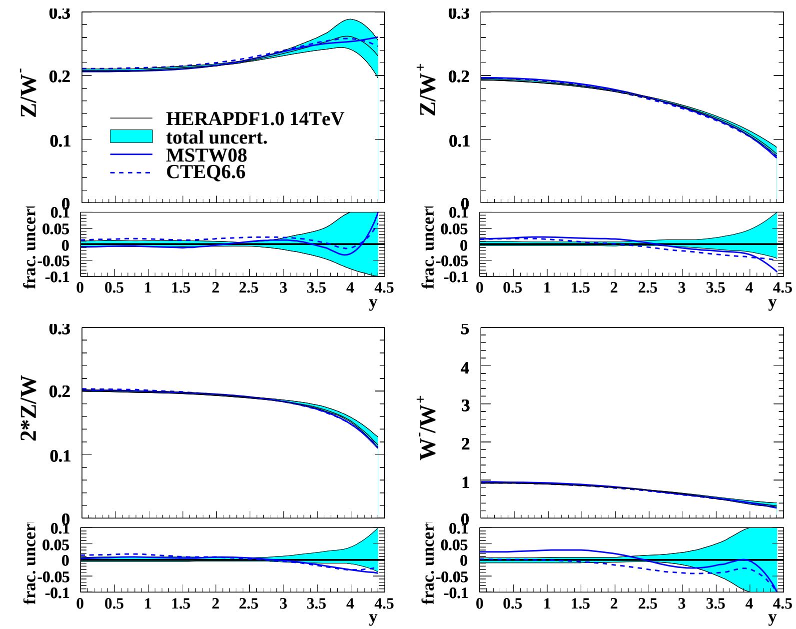
Distributions for valence quarks, see and gluons

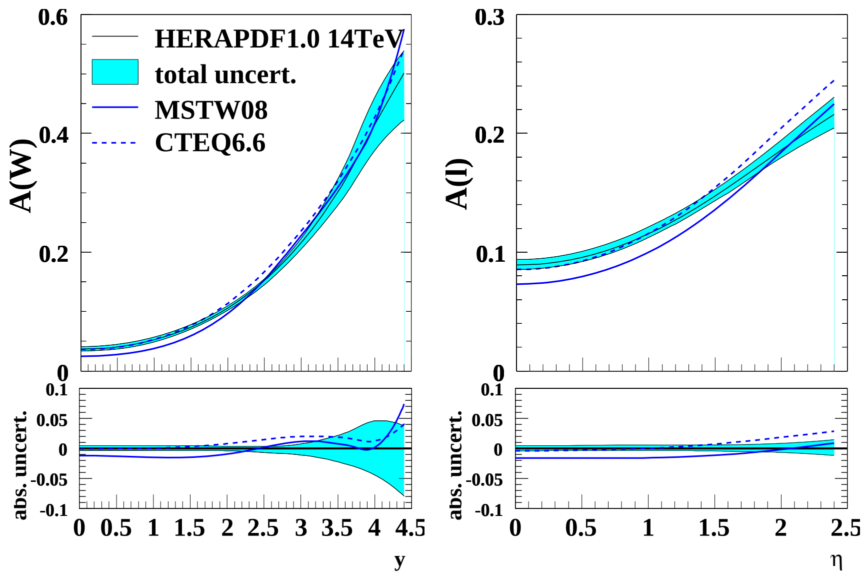
CDF jet data with HERAPDF1.0











HERAPDF1.0 predictions for W/Z production at LHC

These are at 14TeV but 10TeV and 7TeV exist

These show the full uncertainty bands of HERAPDf1.0 and compare to CTEQ66 and MSTW08 central values

Procedural Uncertainties

1. **Additive vs Multiplicative nature of the error sources**

Only normalizations uncertainties are taken as multiplicative
(=> Typically below 0.5%, a few % at high-Q2)
A general study of the possible correlated systematic uncertainties between H1 and ZEUS has been performed:
- Identified 12 possible uncertainties of common origin
- compared 2^{12} averages taking all pairs as corr/uncor in turn

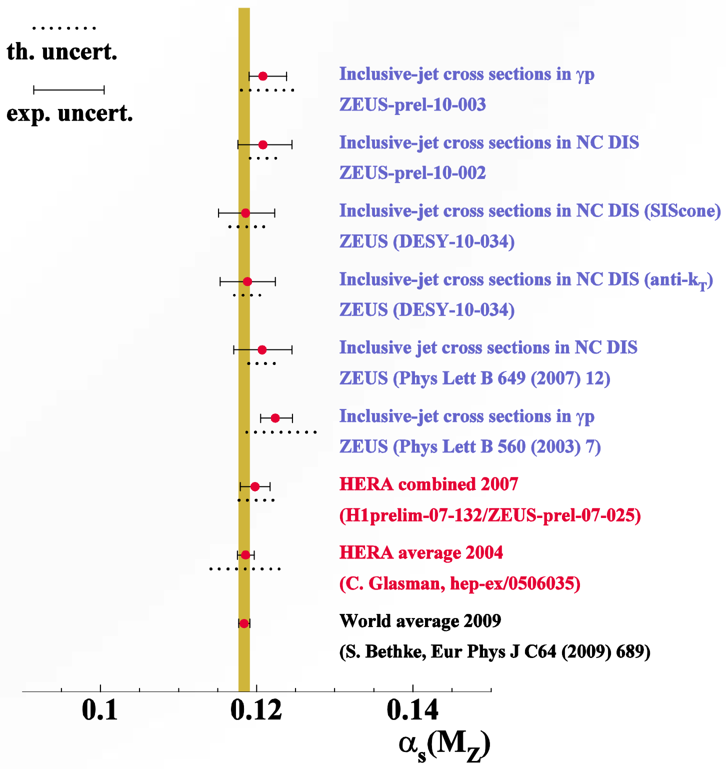
Mostly negligible except for:

2. **Correlated syst. uncert. for the photoproduction background**

(Typically below 0.5%, but larger at high-y)

3. **Correlated syst. uncert. for the hadronic energy scale**

(Typically below 0.5%, significant only at low-y)


th. uncert.
exp. uncert.
Inclusive-jet cross sections in γp
ZEUS-prel-10-003
Inclusive-jet cross sections in NC DIS
ZEUS-prel-10-002
Inclusive-jet cross sections in NC DIS (SIScone)
ZEUS (DESY-10-034)
Inclusive-jet cross sections in NC DIS (anti-k_T)
ZEUS (DESY-10-034)
Inclusive jet cross sections in NC DIS
ZEUS (Phys Lett B 649 (2007) 12)
Inclusive-jet cross sections in γp
ZEUS (Phys Lett B 560 (2003) 7)
HERA combined 2007
(H1prelim-07-132/ZEUS-prel-07-025)
HERA average 2004
(C. Glasman, hep-ex/0506035)
World average 2009
(S. Bethke, Eur Phys J C64 (2009) 689)
0.1
0.12
0.14
$\alpha_s(M_Z)$