Hadronic Final states and extraction of α_s and parton densities

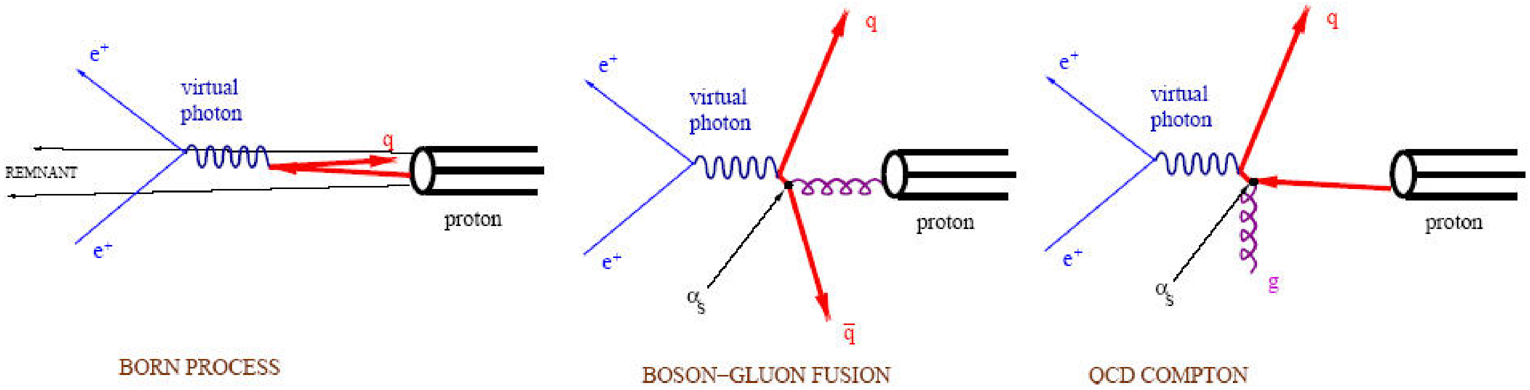
A.M Cooper-Sarkar, Oxford

on behalf of ZEUS and H1

Ringberg 2005

- Use of jet production data for precision measurements of $\alpha_s(M_Z)$
- Use of jet production data to establish running $\alpha_s(Q^2)$
- Use of jet production data in PDF fits – particularly to determine the gluon PDF and to reduce the error which comes from the uncertainty on $\alpha_s(M_Z)$
- Future plans- immediate
- - after HERA-II

Inclusive jet production



High-E_T jet production in the Breit Frame:

LO contributions:

- boson-gluon fusion: $\gamma + g \rightarrow q + \bar{q}$
- QCD-Compton: $\gamma + q \rightarrow q + g$

=> Directly sensitive to α_s and gluon/quark density in the proton

How to use jet data to extract αs(MZ)

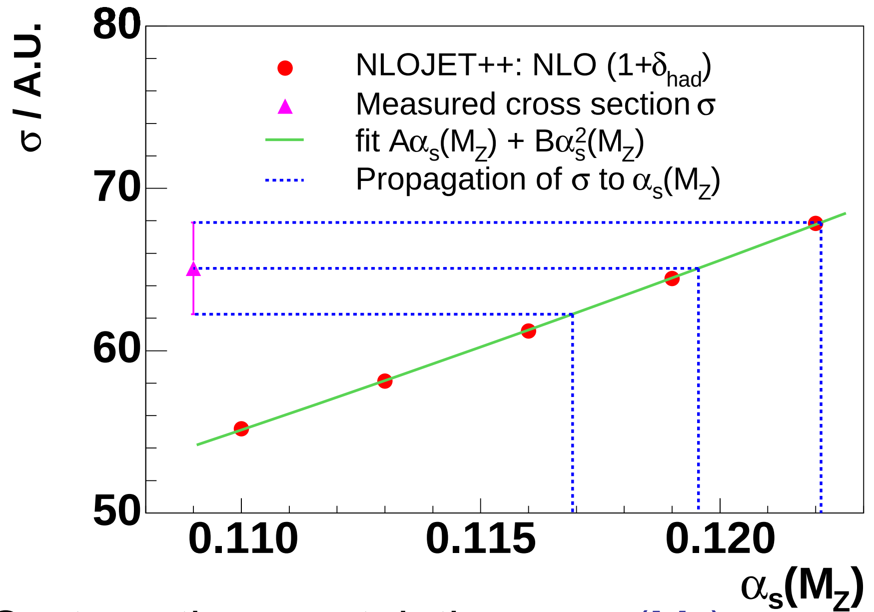
the general method

- Use a programme (like NLOJET or DISENT) which predicts NLO QCD cross-sections for jet production to predict the subcross-section for a particular bin i for several different fixed values of $\alpha_s(M_Z)$

- Use PDFs which are compatible with these $\alpha_s(M_Z)$ values (CTEQ4A, MRST99, ZEUS-S variable α_s series)

- Fit the predictions for each bin to $\sigma_i(\alpha_s(M_Z)) = A_i\, \alpha_s(M_Z) + B_i\, \alpha_s^2(M_Z)$ to determine A_i, B_i, so that we have a prediction for ANY value of $\alpha_s(M_Z)$

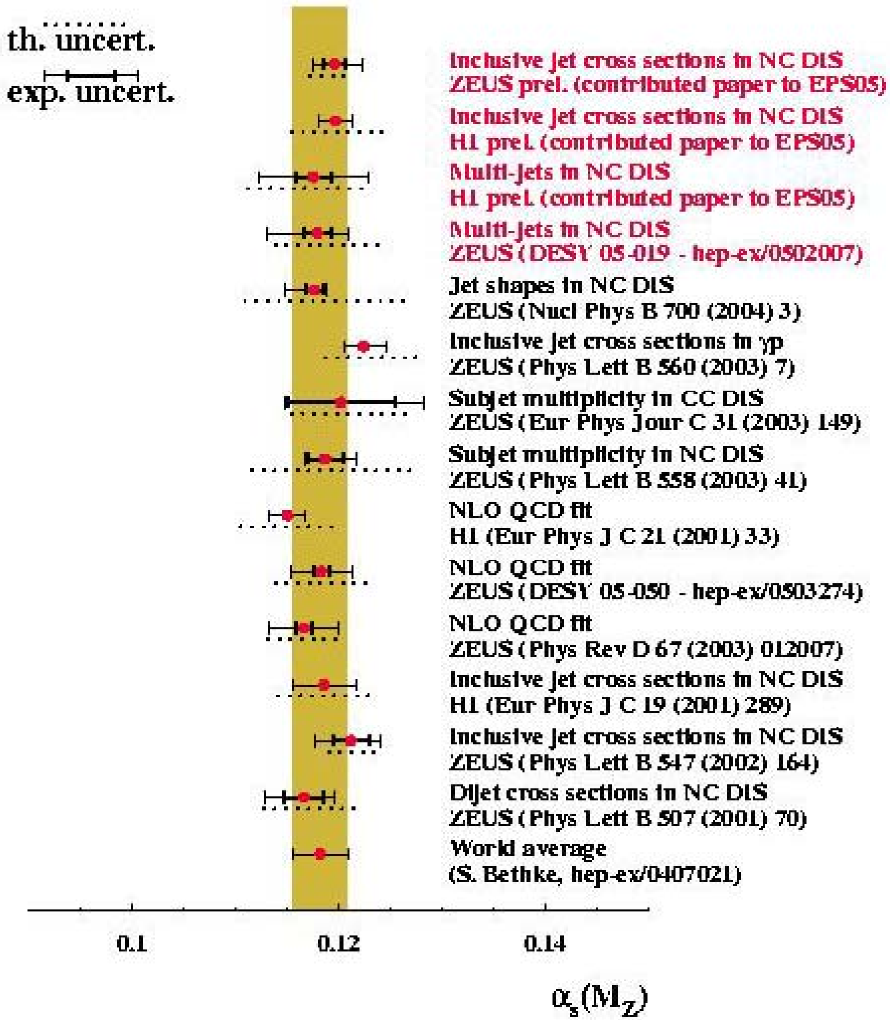
- Map the measured value of the cross-section and its statistical errors onto this function to determine $\alpha_s(M_Z)$ and its statistical errors



Systematic uncertainties on $\alpha_s(M_Z)$ are evaluated by repeating the procedure with the measurement shifted according to each source of systematic uncertainty.

Theoretical uncertainties are evaluated by repeating the procedure with the predictions shifted according to different theoretical assumptions

ZEUS/HERA α_s determinations



C. Glasman

The situation at EPS05 is illustrated here

There are results from jet production and inclusive DIS

Results from jet production have the smallest theoretical uncertainties for inclusive jet production and di-jet/single-jet or tri-jet/di-jet ratios

A HERA average

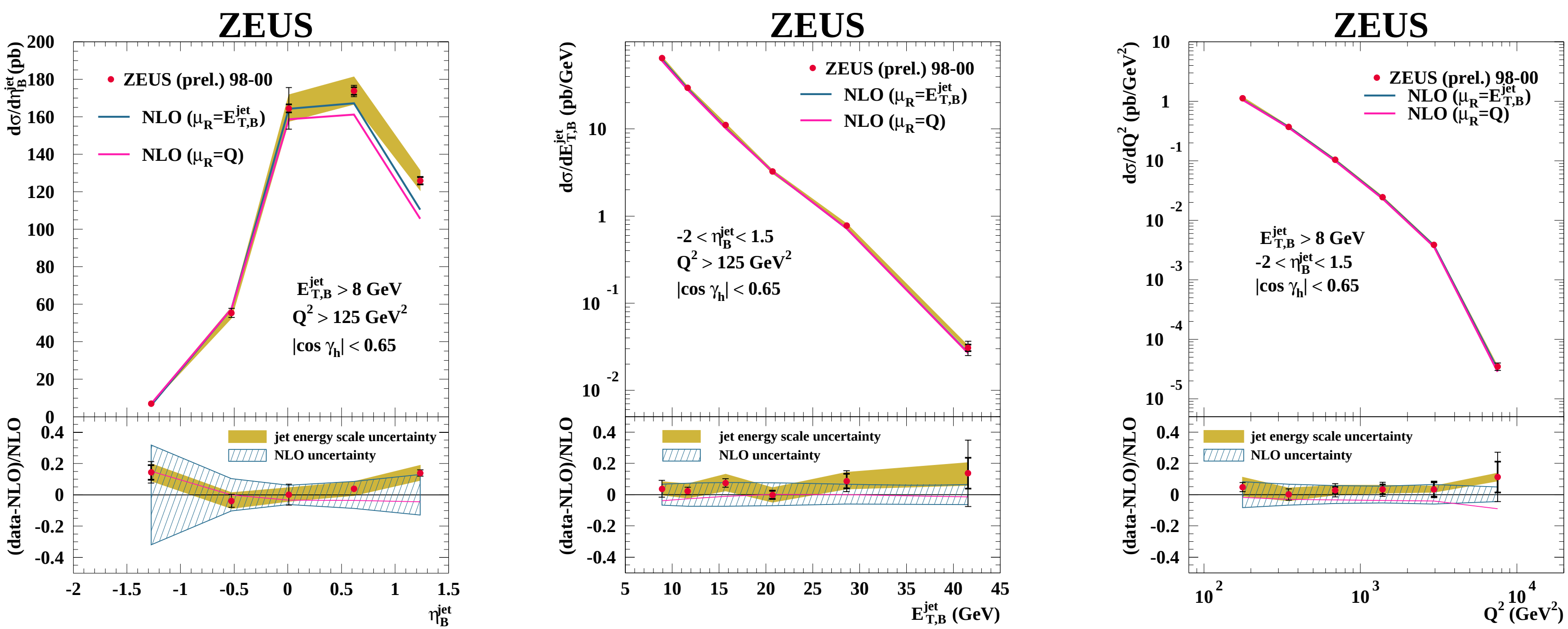
$\alpha_s(M_Z) = 0.1186 \pm 0.0011(\text{exp}) \pm 0.0050(\text{th})$

Uses known experimental correlations within each experiment, full correlation of theoretical scale uncertainties, but assumes no ZEUS/H1 correlation.

There have been new results recently

………

ZEUS Inclusive jet production in NC DIS HEP 2005 paper 375



Jet production cross-sections from 81.7 pb^{-1} of 98/00 data are very well described by predictions of NLO QCD

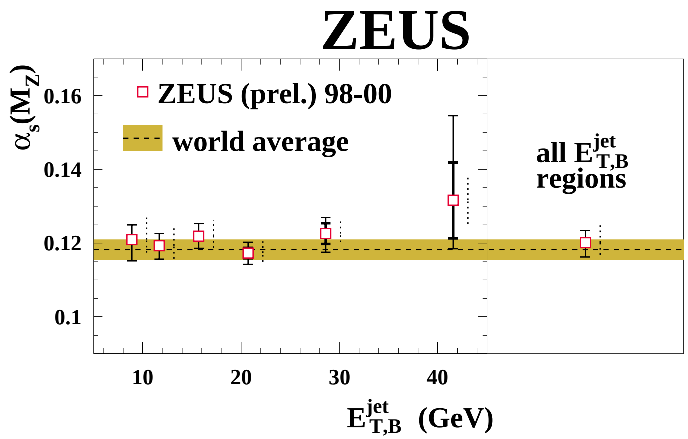
Jet cross sections for Q2 > 125 GeV2 compared to predictions from DISENT

μR = μF = ET, or Q, αs(MZ)= 0.1175, MRST99 PDFs

Plus hadronisation corrections and Z0 corrections

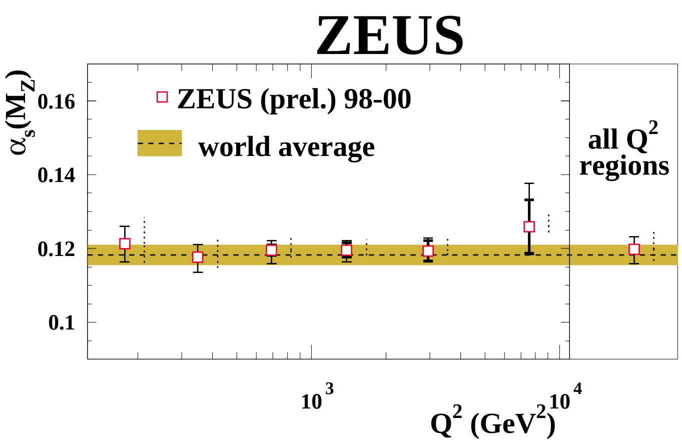
Largest experimental systematic uncertainty from absolute energy scale of jets ⇒ 5%

Largest theoretical uncertainty from varying μR by a factor of 2 ⇒ 5%



Method applied to $d\sigma/dE_T$ in E_T bins and to all E_T bins at once

$\alpha_s(M_Z) = 0.1201 \pm 0.0006(\text{stat})\ ^{+0.0033}_{-0.0038}(\text{sys})\ ^{+0.0049}_{-0.0032}(\text{th})$



Method applied to $d\sigma/dQ^2$ in Q^2 bins and to all Q^2 bins at once

$\alpha_s(M_Z) = 0.1198 \pm 0.0006(\text{stat})\ ^{+0.0034}_{-0.0039}(\text{sys})\ ^{+0.0049}_{-0.0033}(\text{th})$

Best result for Q2 bins, Q2 > 500 GeV2 –uncertainties minimised

$\alpha_s(M_Z) = 0.1196 \pm 0.0011\ (\text{stat})\ ^{+0.0019}_{-0.0025}\ (\text{sys})\ ^{+0.0029}_{-0.0017}\ (\text{th})$

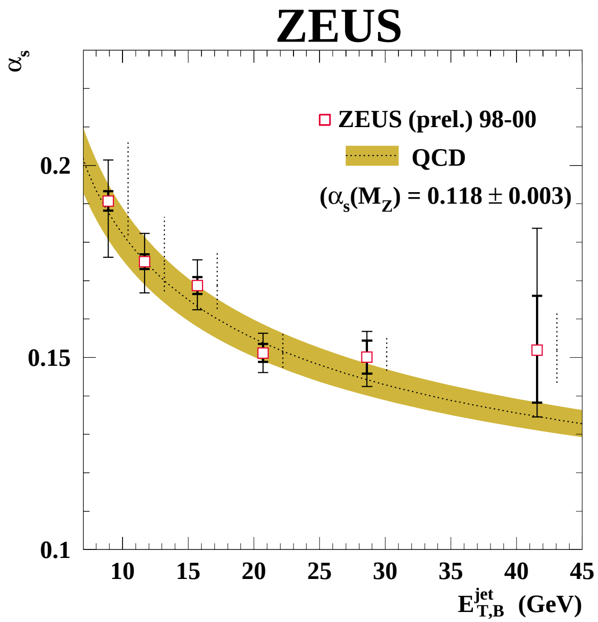
Compare result from 96/97 data

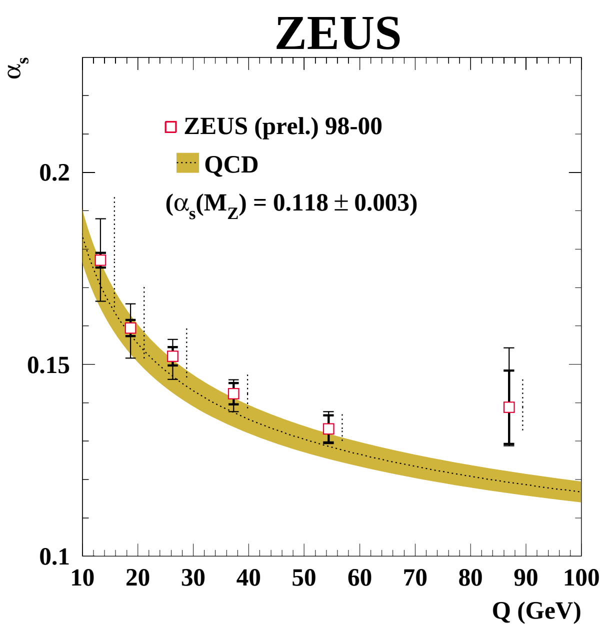
$\alpha_s(M_Z) = 0.1212 \pm 0.0017\ (\text{stat})\ ^{+0.0023}_{-0.0031}\ (\text{sys})\ ^{+0.0028}_{-0.0027}\ (\text{th})$

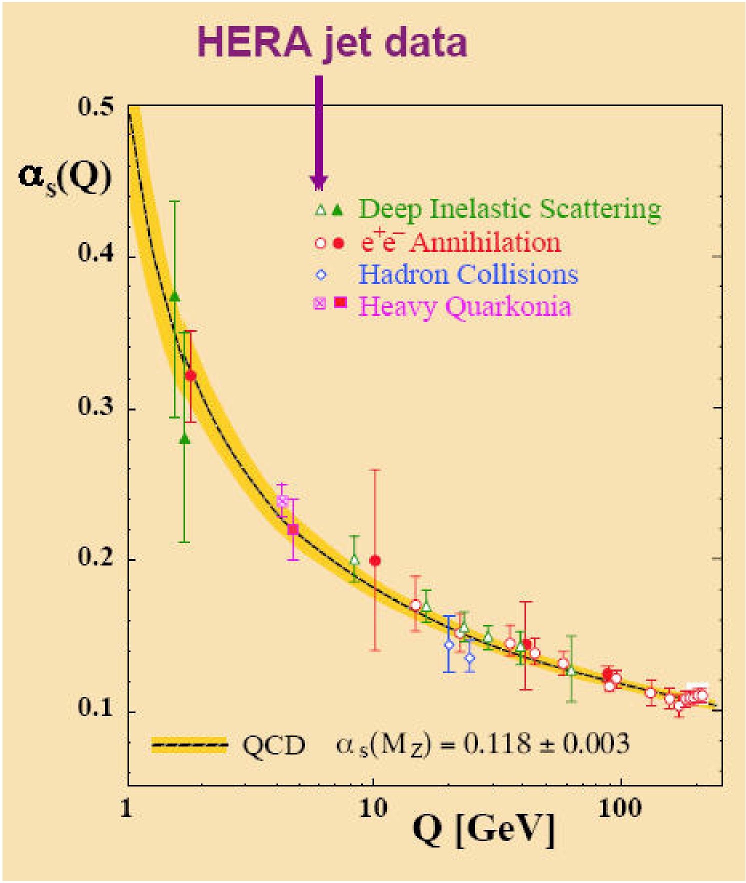
Improvement in statistics $\Rightarrow$ improvement in estimate of systematics

Method can also be applied to fit for $\alpha_s(<E_T>)$ or $\alpha_s(<Q>)$ to <u>investigate the running of α_s with scale</u>

Compare with world data

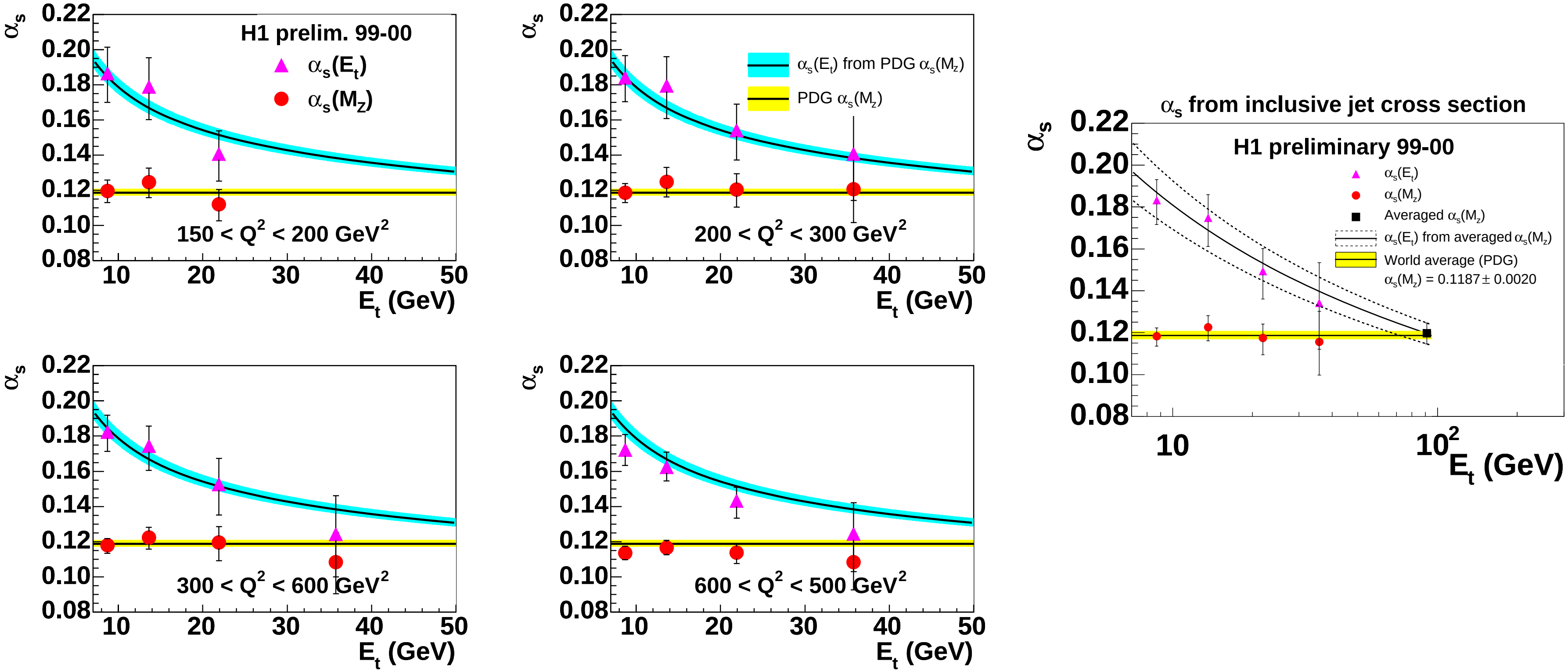






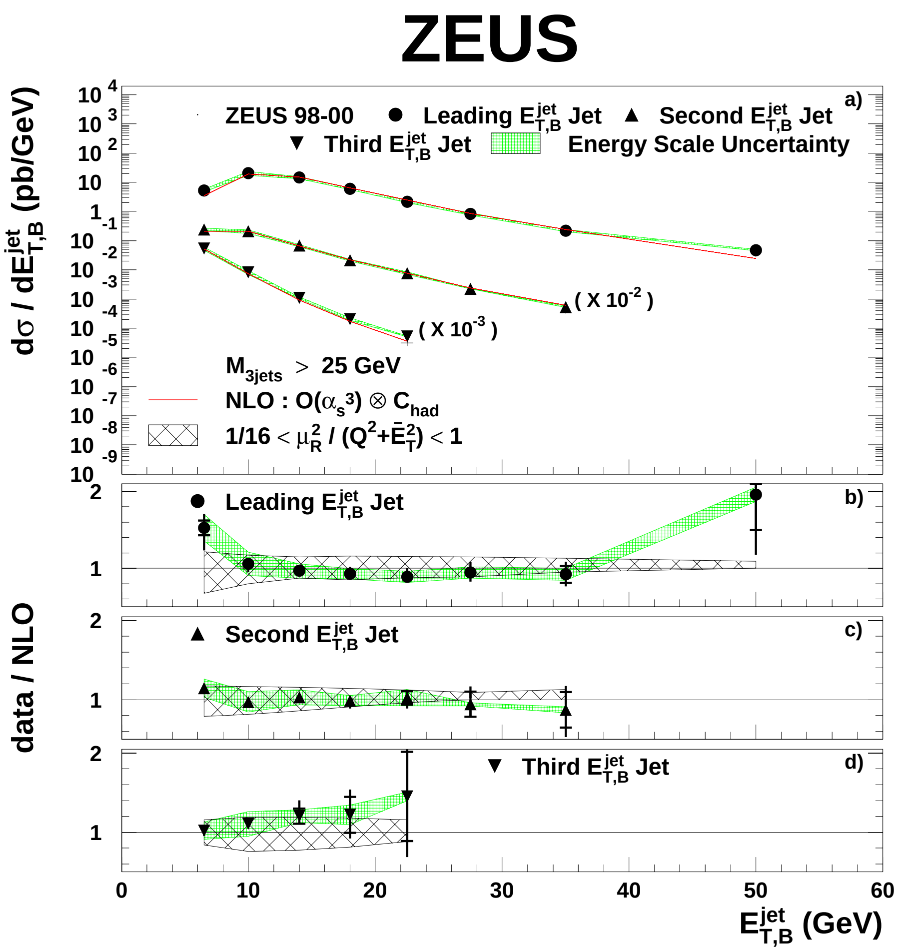
C. Glasman @ DIS05

H1 Inclusive jet production in NC DIS HEP-2005 paper 629



H1 have used a similar method on 61pb-1 of 99/00 data, using NLOJET++ and CTEQ5M PDFs for the jet predictions in Q^2,E_T and E_T bins

$$\alpha_s(M_Z) = 0.1175 \pm 0.0016\ (\text{exp})\ ^{+0.0046}_{-0.0048}\ (\text{th})$$



Largest experimental uncertainty- calorimeter energy scale

Largest theoretical uncertainty- renorm and factorisation scale

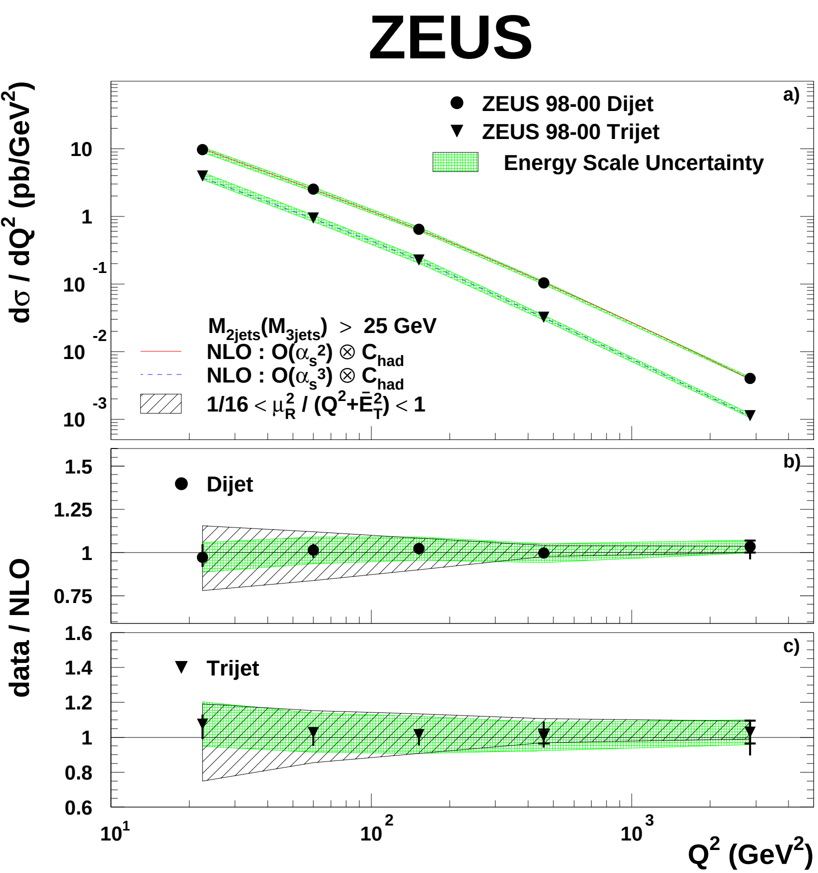
Have previously used the di-jet/single-jet cross-sections to extract αs(MZ) Phys.Lett.507(2001)70.

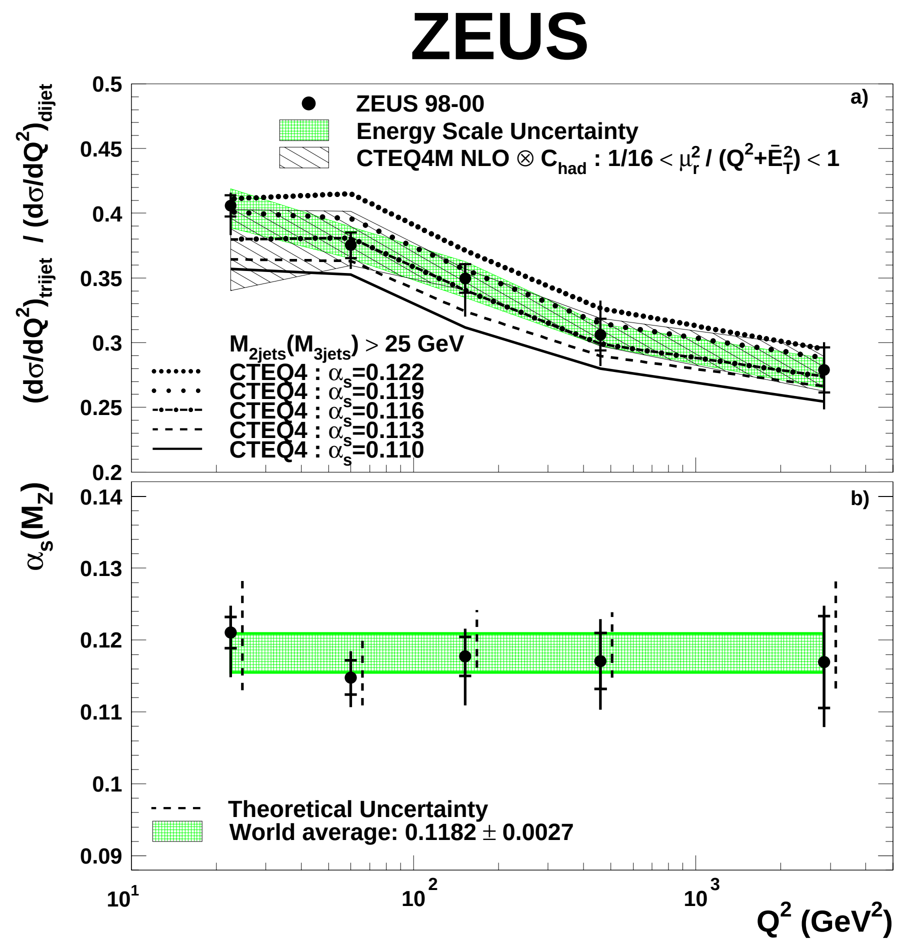
Now use the same idea on tri-jet/di-jet cross sections. There is higher sensitivity to $\alpha_s(M_Z)$ in tri-jet cross-sections, and we retain the advantage that many correlated experimental and theoretical uncertainties cancel out in ratio.

82pb-1 of 98/00 data.

Need NLOJET for trijet cross-section prediction, CTEQ6 PDFs and $\mu_R=\mu_F=(E_T^2+Q^2)/4$,

where Et is the average Et of the two or three jets.



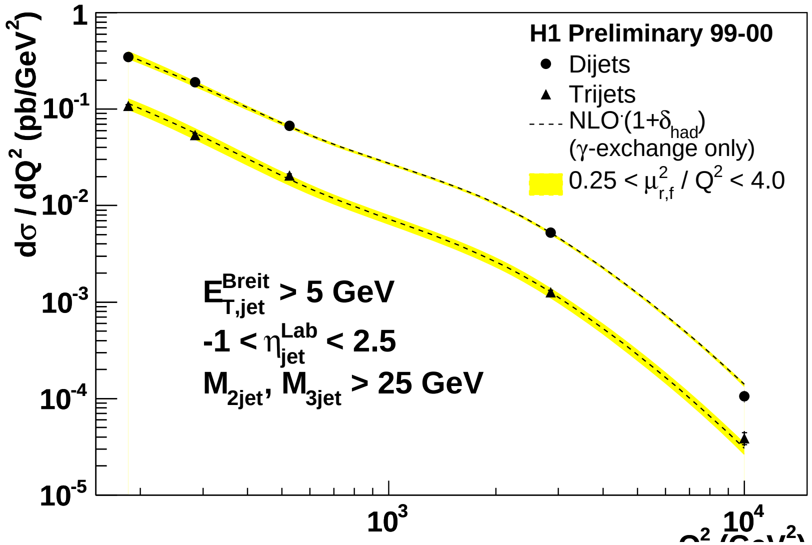


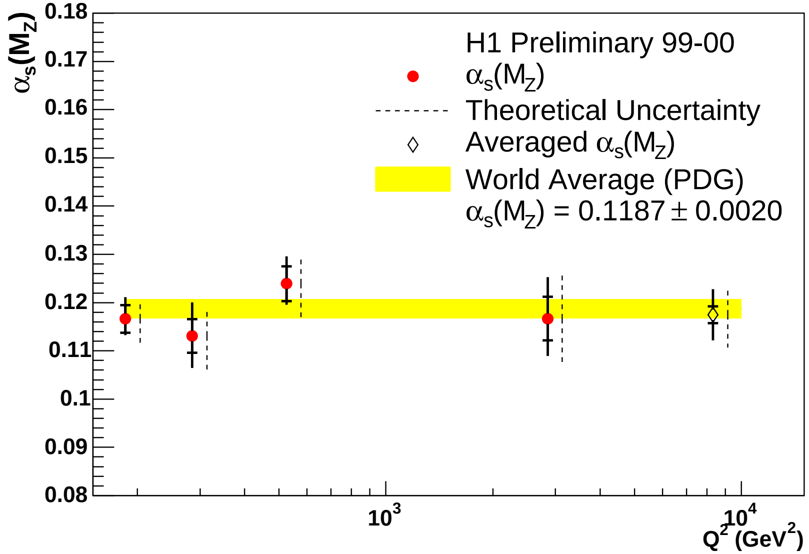
The usual method to extract $\alpha_s(M_Z)$ is applied to predictions of R3/2($\alpha_s(M_Z)$) using the CTEQ4A series for PDFs with different $\alpha_s(M_Z)$ values

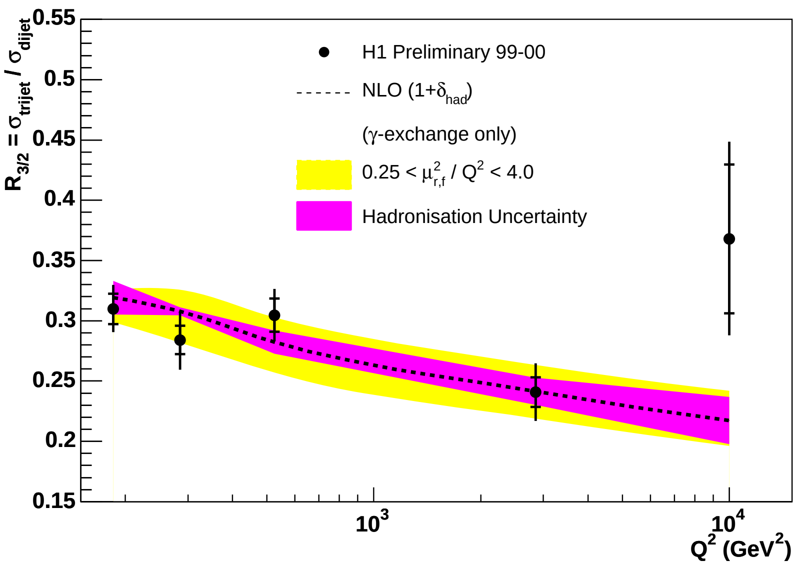
$\alpha_s(M_Z) = 0.1179 \pm 0.0013\ (\text{stat})\ ^{+0.0028}_{-0.0046}\ (\text{sys})\ ^{+0.0054}_{-0.0046}\ (\text{th})$

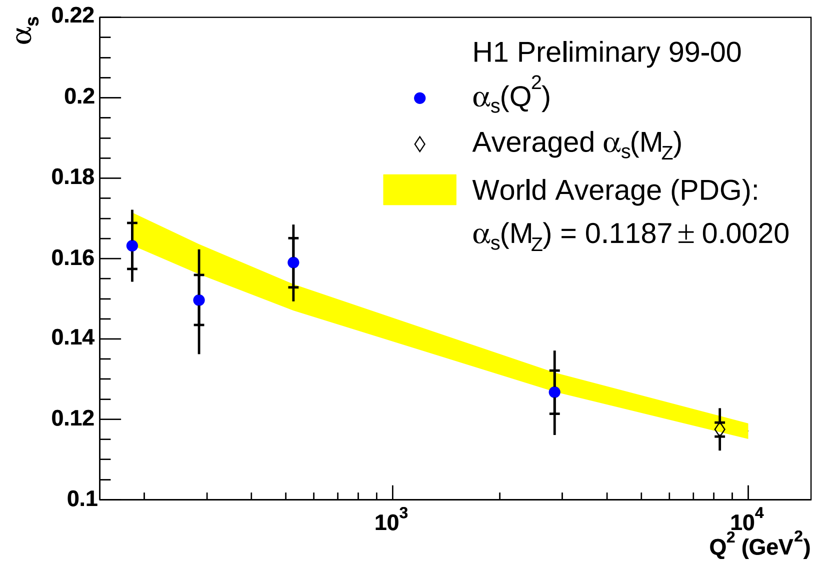
H1 Multi-jet production in high Q2 NC –HEP2005-625

$$\alpha_s(M_Z) = 0.1175 \pm 0.0017\ \text{(stat)} \pm 0.005\text{(sys)}\ ^{+0.0054}_{-0.0068}\ \text{(th)}$$









<u>Using jet data in PDF fits</u> – pioneering paper H1 Eur.Phys.J.C19(2001)289 but for $\alpha_s(M_Z)$ and gluon PDF only

Where does the information come from in a global fit compared to a fit including only ZEUS data ?

	Global	**HERA Only**
Valence	Predominantly fixed target data (ν-Fe and μD/μp)	High Q^2 NC/CC $e^{\pm}$ cross sections
Sea	Low-x from NC DIS High-x from fixed target Flavour from fixed target	Low-x from NC DIS High-x less precise Flavour ?(need assumptions)
Gluon	Low-x from HERA $dF_2/d\ln Q^2$ High-x from Tevatron jets and momentum sum rule	Low-x from HERA $dF_2/d\ln Q^2$ High-x from jet data and momentum sum rule

<u>ANALYSES FROM HERA ONLY …</u>

— Systematics well understood - measurements from our own experiment

—No complications from heavy target Fe or D corrections

—No assumption on strong isospin

Data sets

- A total of 577 data points from 112pb-1 of data
- Kinematic region:

  $2.7 < Q^2 < 30\,000$ GeV^2
  $6.3\ 10^{-5} < x < 0.65$
  $W^2 > 20$ GeV^2

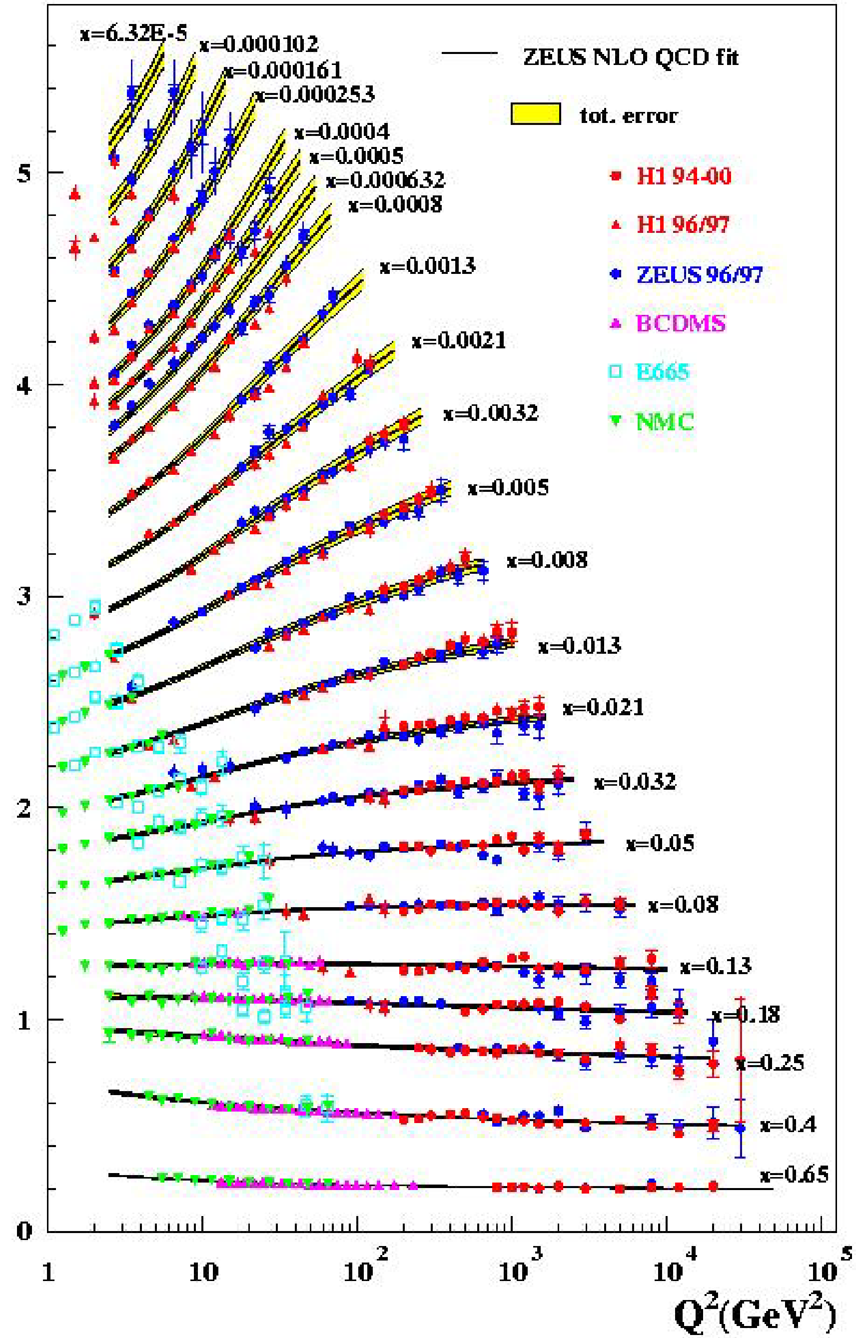
- Full account of the correlated systematic uncertainties
- A good description of the measured cross sections is obtained with:

χ^2/data-points	470/577

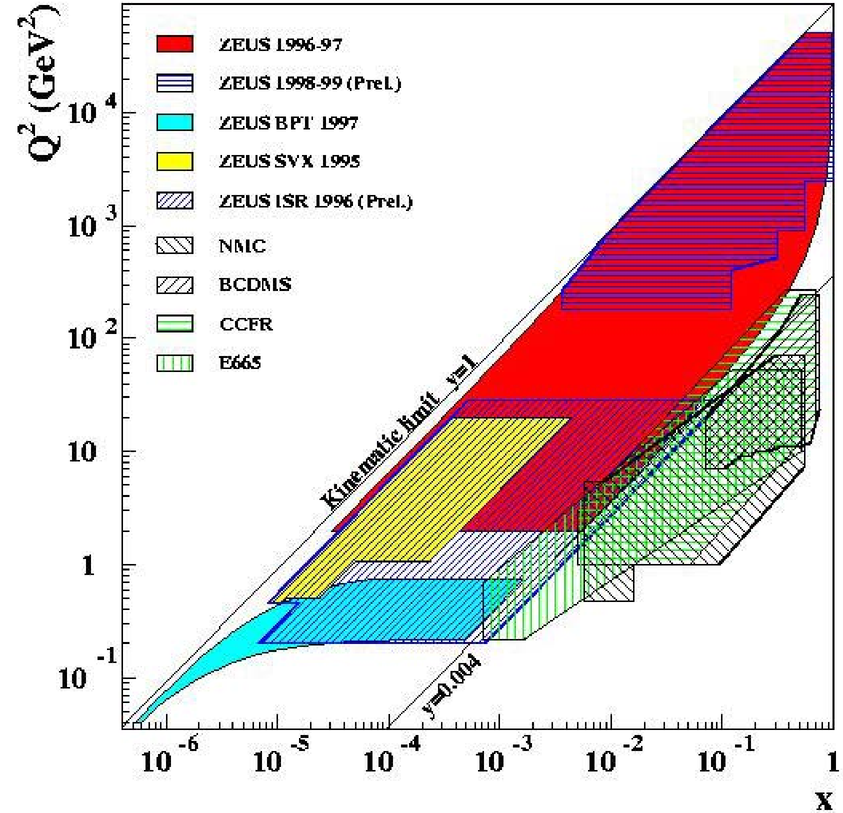
ZEUS Data Set	Ndata	Kinematic Region
NC e^+p 96-97	242	$2.7 < Q^2 < 30\,000$ GeV^2 $6.3\ 10^{-5} < x < 0.65$
CC e^+p 94-97	29	$280 < Q^2 < 17\,000$ GeV^2 $0.015 < x < 0.42$
NC e^-p 98-99	92	$200 < Q^2 < 30\,000$ GeV^2 $0.005 < x < 0.65$
CC e^-p 98-99	26	$280 < Q^2 < 17\,000$ GeV^2 $0.015 < x < 0.42$
NC e^+p 99-00	90	$200 < Q^2 < 30\,000$ GeV^2 $0.005 < x < 0.65$
CC e+p 99-00	30	$280 < Q^2 < 17\,000$ GeV^2 $0.008 < x < 0.42$
DIS jets e^+p 96-97	30	$125 < Q^2 < 30\,000$ GeV^2 $8 < E^B_T < 100$ GeV
γp dijets e^+p 96-97	38	$14 < E^{jet1}_T < 75$ GeV

ZEUS-JETS and ZEUS-JETS-α_s fits

Bjorken scaling is broken – ln(Q^2)



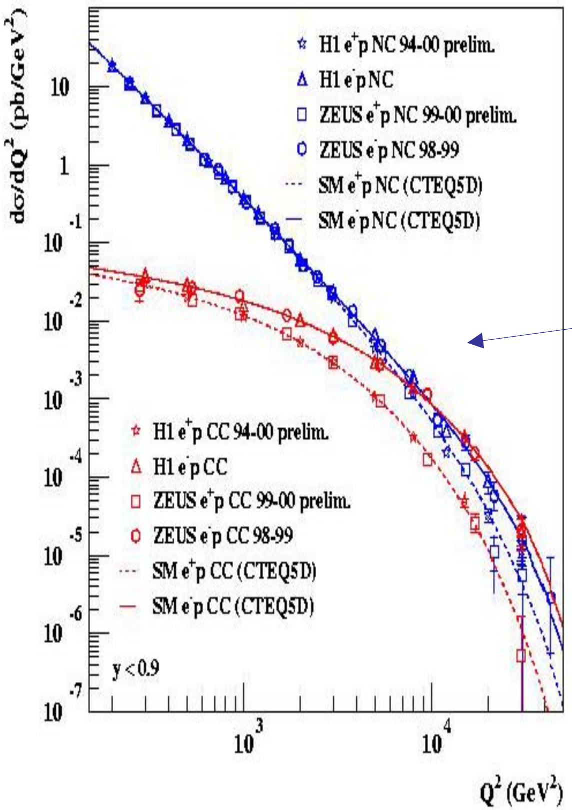
Note strong rise at small x



Terrific expansion in measured range across the x, Q^2 plane throughout the 90's

HERA data

Pre HERA fixed target $\mu p, \mu D$ NMC,BDCMS, E665 and $\nu, \bar{\nu}$ Fe CCFR



HERA data 98-00 have provided information at high $Q^2 \to Z^0$ and $W^{+/-}$ become as important as γ exchange $\to$ NC and CC cross-sections comparable

For NC processes

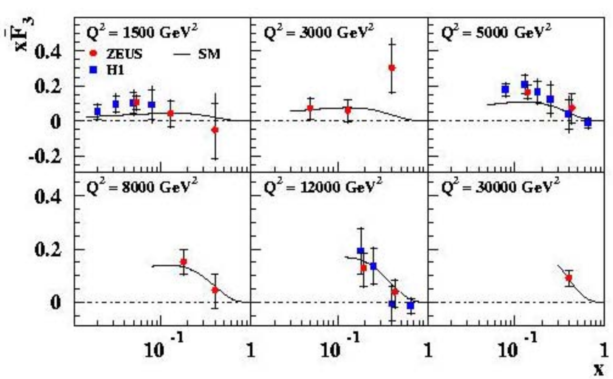
$$F_2 = \Sigma_i \, A_i(Q^2) \, [xq_i(x,Q^2) + x\bar{q}_i(x,Q^2)]$$

$$xF_3 = \Sigma_i \, B_i(Q^2) \, [xq_i(x,Q^2) - x\bar{q}_i(x,Q^2)]$$

$$A_i(Q^2) = e_i^2 - 2\, e_i \, v_i \, v_e \, P_Z + (v_e^2 + a_e^2)(v_i^2 + a_i^2) \, P_Z^2$$

$$B_i(Q^2) = \quad -2\, e_i \, a_i \, a_e \, P_Z + \quad 4 a_i \, a_e \, v_i \, v_e \quad P_Z^2$$

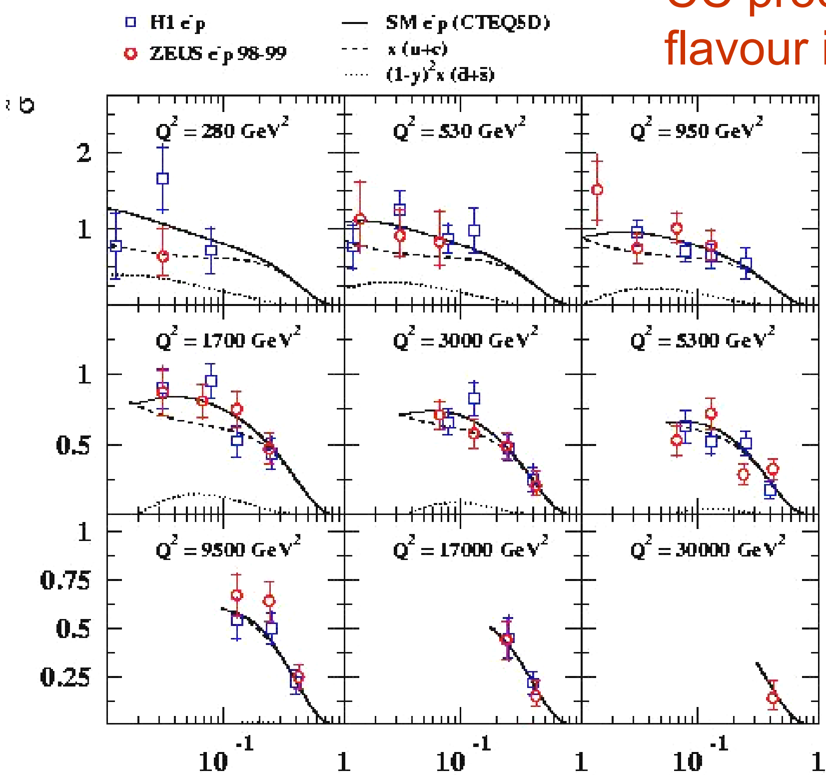
$$P_Z^2 = Q^2/(Q^2 + M_Z^2) \; 1/\sin^2\theta_W$$

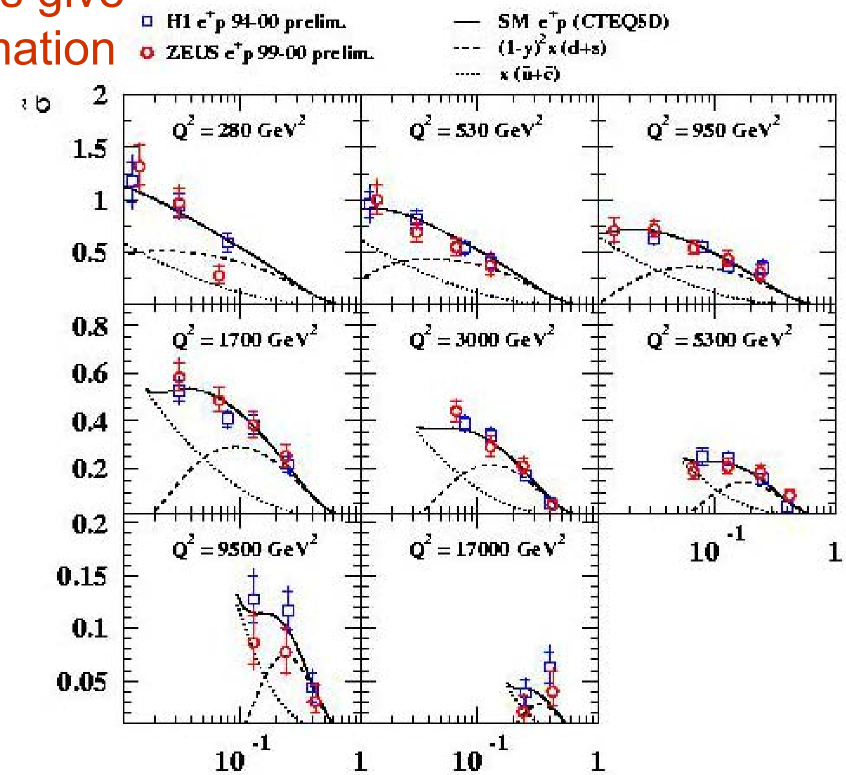


$\to$a new valence structure function xF_3 due to Z exchange is measurable from low to high x- on a pure proton target $\to$ no heavy target corrections- no assumptions about strong isospin

$\to$ e- running at HERA-II will greatly improve this measurement

CC processes give flavour information





$$\frac{d^2\sigma(e^-p)}{dxdy} = \frac{G_F^2 M_W^4}{2\pi x(Q^2+M_W^2)^2}\left[x\,(u+c) + (1-y)^2 x\,(\bar{d}+\bar{s})\right]$$

u_v at high x

M_W information

$$\frac{d^2\sigma(e^+p)}{dxdy} = \frac{G_F^2 M_W^4}{2\pi x(Q^2+M_W^2)^2}\left[x\,(\bar{u}+\bar{c}) + (1-y)^2 x\,(d+s)\right]$$

d_v at high x

Measurement of high-x d_v on a pure proton target

(even Deuterium needs corrections. Does $d_v/u_v \Rightarrow 0$, as $x \Rightarrow 1$?

Does u in proton = d in neutron?)

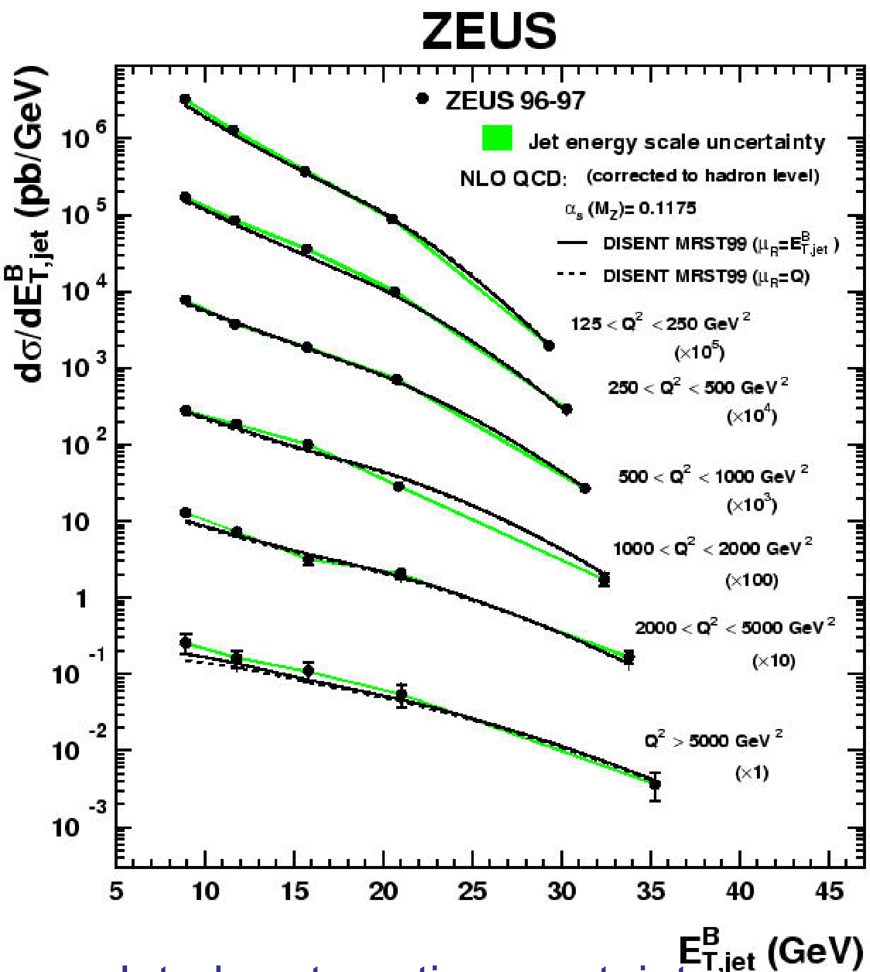
Inclusive Jet Cross Sections in e^+p NC DIS

ZEUS coll., PL B547 164 (2002)

- Phase space:
  $Q^2 > 125$ GeV^2
  $E^B_{T,jet} > 8$ GeV and $-2 < \eta^B_{jet} < 1.8$
-
- Jets identified with the k_T cluster algorithm in the Breit frame

- Small Experimental uncertainties:
  → jet energy scale (~1% for $E_{T,jet}$>10 GeV)
  => ± 5% on the cross sections

- Small theoretical uncertainties:
  - higher order terms ± 5%
  - Hadronic corrections
  (C_{had} <10 % and ΔC_{had} ~ 1%)



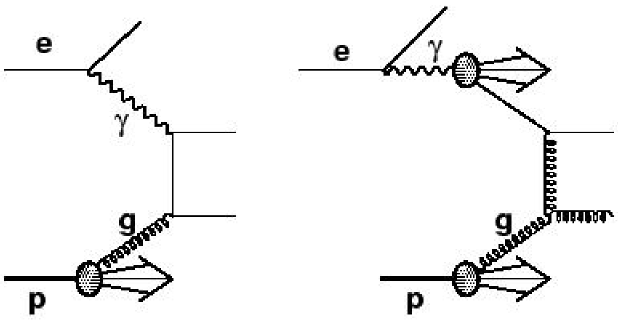
The calorimeter energy scale is treated as a correlated systematic uncertainty
The factorization scale, μ_F= Q, renormalization scale μ_R=Q, (ET as a cross-check)

Dijet photoproduction

Measure dijet production in γp collisions via ep scattering for $Q^2 \sim 0$

At LO two processes contribute =>

Direct sensitivity to α_s and proton gluon PDFs



Direct process Resolved process

But for the resolved process there will be some sensitivity to the photon PDFs. So the PDF fit analysis was restricted to the direct-process-enriched region, $x_\gamma^{obs} > 0.75$, where

$$X_\gamma^{obs} = \sum_i E_T^{jet_i} \exp(-\eta^{jet_i}) / (2yE_e)$$

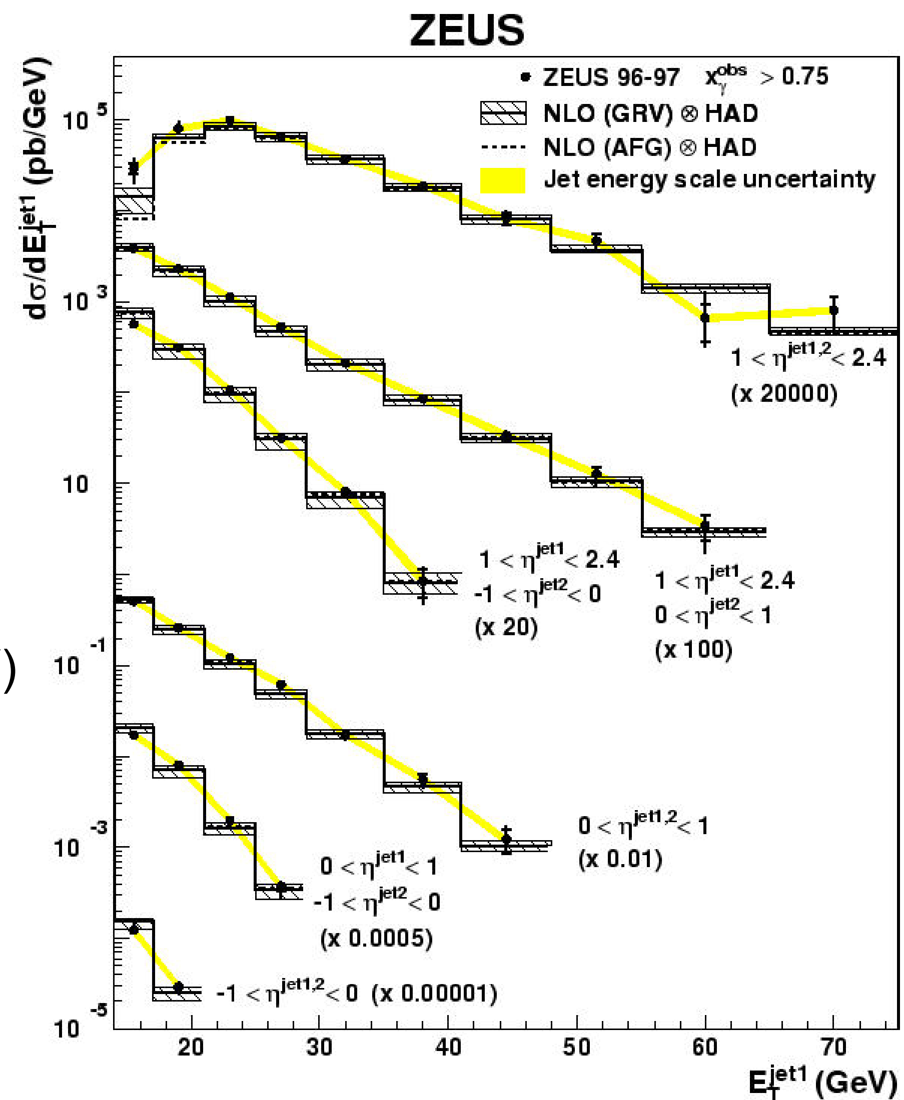
is the fraction of the photon's momentum taking part in the hard process.

At NLO one cannot make this distinctions precisely, there will be some sensitivity to photon PDFs even in the direct enriched sample- The AFG photon PDF is used, and the CJK and GRV photon PDFs are used as checks

Dijet γp cross sections for $x_\gamma^{obs} > 0.75$

ZEUS Coll., EPJ C23 615 (2002)

- Phase space:
  $E_T^{jet1,(2)} > 14$ (11) GeV and
  $-1 < \eta^{jet1,2} < 2.4$ and $x_\gamma^{obs} > 0.75$
  and
  $Q^2 < 1$ GeV^2 and $134 < W_{\gamma p}{}^2 < 277$ GeV^2
- Jets identified with the k_T cluster algorithm in the Lab frame
- Small Experimental uncertainties:
  → jet energy scale (~1% for $E_{T,jet}$>10 GeV)
  => ± 5% on the cross sections
- Small theoretical uncertainties:
  - higher order terms ± 10%
  - Hadronic corrections
  (C_{had} <10 % and ΔC_{had} ~ 2-3%)



The calorimeter energy scale is treated as a correlated systematic uncertainty
The factorization and renormalization scales, $\mu_F = \mu_R = ET/2$ (summed ET of final state particles)

Recap of the method

- $xuv(x) = Au\ x^{av}\ (1-x)^{bu}\ (1 + c_u\ x)$
  $xdv(x) = Ad\ x^{av}\ (1-x)^{bd}\ (1 + c_d\ x)$
  $xS(x) = As\ x^{as}\ (1-x)^{bs}\ (1 + c_s\ x)$
  $xg(x) = Ag\ x^{ag}\ (1-x)^{bg}\ (1 + c_g\ x)$
  $x\Delta(x) = x(d-u) = A\Delta\ x^{av}\ (1-x)^{bs+2}$

Parametrize parton distribution functions PDFs at $Q^2_0 = 7\ \text{Gev}^2$ →

Evolve in Q^2 using NLO DGLAP (QCDNUM 16.12) →

$$\frac{\partial \mathbf{q_i}(\mathbf{x}, \mathbf{Q^2})}{\partial \log \mathbf{Q^2}} = \frac{\alpha_\mathbf{S}}{\mathbf{2}\pi} \int_\mathbf{x}^1 \frac{\mathbf{dy}}{\mathbf{y}} \Big\{ \mathbf{P_{q_i q_j}}(\mathbf{y}, \alpha_\mathbf{S})\ \mathbf{q_j}(\frac{\mathbf{x}}{\mathbf{y}}, \mathbf{Q^2}) + \mathbf{P_{q_i g}}(\mathbf{y}, \alpha_\mathbf{S})\ \mathbf{g}(\frac{\mathbf{x}}{\mathbf{y}}, \mathbf{Q^2}) \Big\}$$

$$\frac{\partial \mathbf{g}(\mathbf{x}, \mathbf{Q^2})}{\partial \log \mathbf{Q^2}} = \frac{\alpha_\mathbf{S}}{\mathbf{2}\pi} \int_\mathbf{x}^1 \frac{\mathbf{dy}}{\mathbf{y}} \Big\{ \mathbf{P_{g q_j}}(\mathbf{y}, \alpha_\mathbf{S})\ \mathbf{q_j}(\frac{\mathbf{x}}{\mathbf{y}}, \mathbf{Q^2}) + \mathbf{P_{gg}}(\mathbf{y}, \alpha_\mathbf{S})\ \mathbf{g}(\frac{\mathbf{x}}{\mathbf{y}}, \mathbf{Q^2}) \Big\}$$

Convolute PDFs with coefficient functions to give structure functions and hence cross-sections →

$$\frac{F_2(x, Q^2)}{x} = \int_0^1 \frac{dy}{y} \left[\Sigma_i C_2(z, \alpha_s) q_i(x, Q^2) + C_g(z, \alpha_s) g(y, Q^2) \right]$$

Coefficient functions incorporate treatment of Heavy Quarks by Thorne-Roberts Variable Flavour Number

Fit to data under the cuts,

$W^2 > 20\ \text{GeV}^2$ (to remove higher twist),
$30{,}000 > Q^2 > 2.7\ \text{GeV}^2$ ←Use of NLO DGLAP
$x > 6.3\ 10^{-5}$

Model choices ⇒ Form of parametrization at Q^2_0, value of Q^2_{0},, flavour structure of sea, cuts applied, heavy flavour scheme

The χ2 includes the contribution of correlated systematic errors

$$\chi^2 = \sum_i \frac{[\, F_i^{QCD}(p) - \sum_\lambda s_\lambda \Delta_{i\lambda}^{SYS} - F_i^{MEAS}]^2}{(\sigma_i^{STAT})^2} + \sum s_\lambda^2$$

Where $\Delta_{i\lambda}^{SYS}$ is the correlated error on point **i** due to systematic error source **λ** and s_λ are systematic uncertainty fit parameters of zero mean and unit variance

This has modified the fit prediction by each source of systematic uncertainty

The statistical errors on the fit parameters, p, are evaluated from **Δχ2 = 1,** $s_\lambda=0$

The correlated systematic errors are evaluated by the Offset method –conservative method - $s_\lambda=\pm1$ for each source of systematic error

Now use ZEUS data alone - minimizes data inconsistency (but must consider model dependence carefully)

Major source of model dependence is the form of the parametrization at Q^2_0

- $xuv(x) = Au\ x^{av}\ (1-x)^{bu}\ (1 + c_u\ x)$
  $xdv(x) = Ad\ x^{av}\ (1-x)^{bd}\ (1 + c_d\ x)$
  $xS(x) = As\ x^{as}\ (1-x)^{bs}\ (1 + c_s\ x)$
  $xg(x) = Ag\ x^{ag}\ (1-x)^{bg}\ (1 + c_g\ x)$
  $x\Delta(x) = A\Delta\ x^{av}\ (1-x)^{bs+2}$

No $\chi 2$ advantage in more terms in the polynomial

No sensitivity to shape of $\Delta = \bar{d} - \bar{u}$
Assume $s = (\bar{d}+\bar{u})/4$ consistent with ν dimuon data

These parameters control the low-x shape

These parameters control the high-x shape

These parameters control the middling-x shape

Au, Ad, Ag are fixed by the number and momentum sum-rules

Little low-x valence information to distinguish av for u and d valence

→ 13 parameters for a global fit

But with ZEUS data alone we lack information/sensitivity to AΔ – fix to value consistent with Gottfried sum-rule

We also lack information on the high-x Sea – set c_s=0

and on the high-x gluon- unless we add in jet data……..

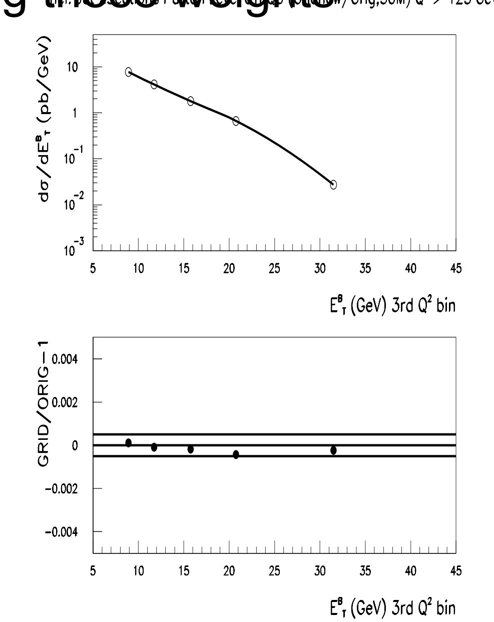
Inclusion of Jet cross sections - pioneering paper H1 Eur.Phys.J.C19(2001)289 made a simultaneous fit to the gluon PDF and $\alpha_s(M_Z)$

Computation of NLO jet cross sections extremely CPU intensive (~ O(10) hours) => original programs cannot be used directly in the fit…

…so we used these programs to compute α_s- and PDF-independent LO/NLO weights, $\tilde{\sigma}$, obtained by integrating the partonic cross sections over the 3(2)-dimensional bins of the (ξ,μ_R,μ_F) space.

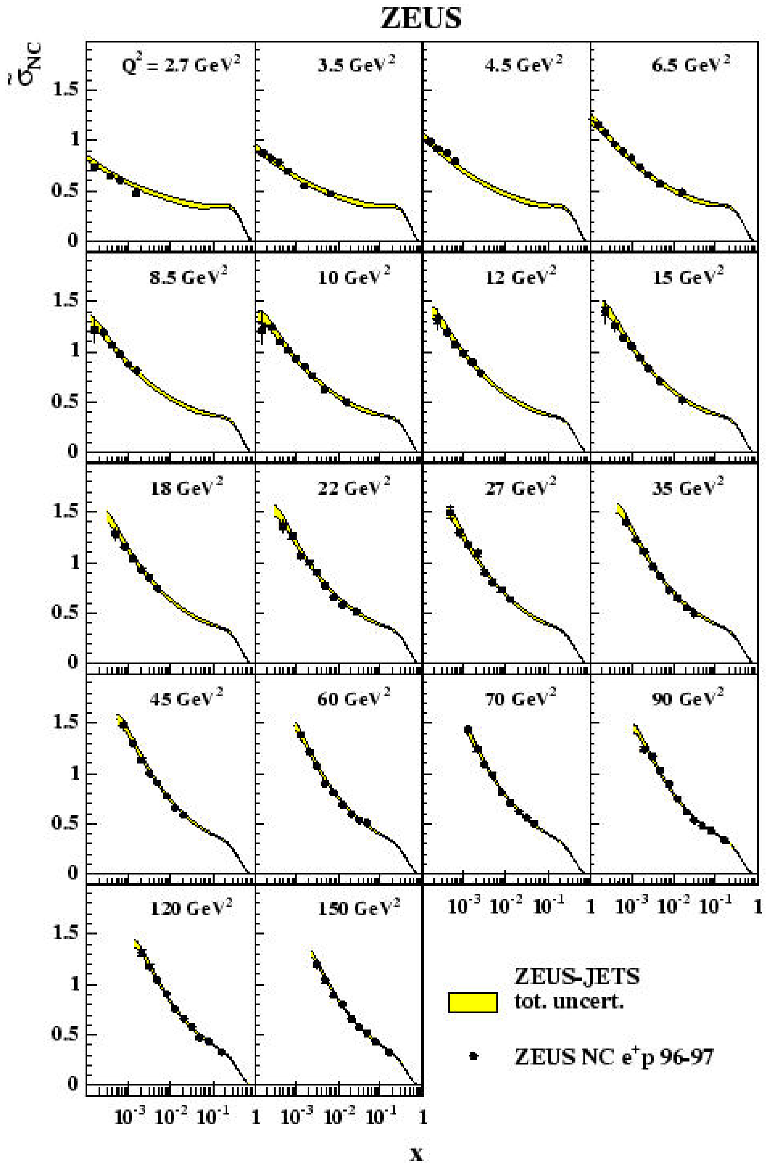
The NLO cross sections were then obtained by folding these weights with the PDFs and α_s according to

$$\sigma = \sum_n \sum_a \sum_{i,j,k} f_a(\langle\xi\rangle_i, \langle\mu_F\rangle_j) \cdot \alpha_s^n(\langle\mu_R\rangle_k) \cdot \tilde{\sigma}^{(n)}_{a,\{i,j,k\}}$$



This procedure reproduces the “exact” NLO predictions to better than 0.5%

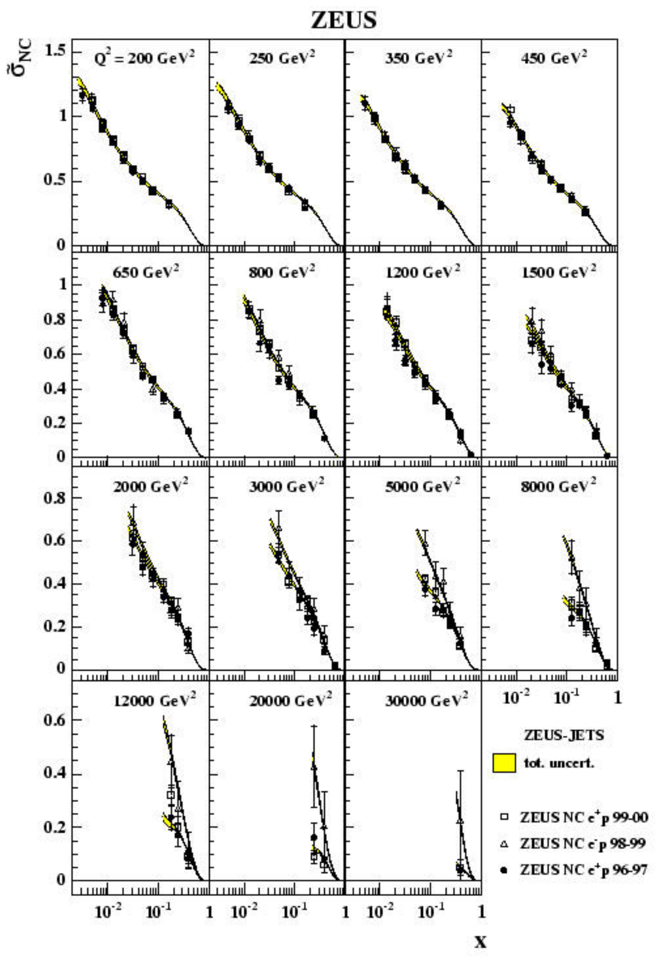
QCD fit results: Inclusive NC



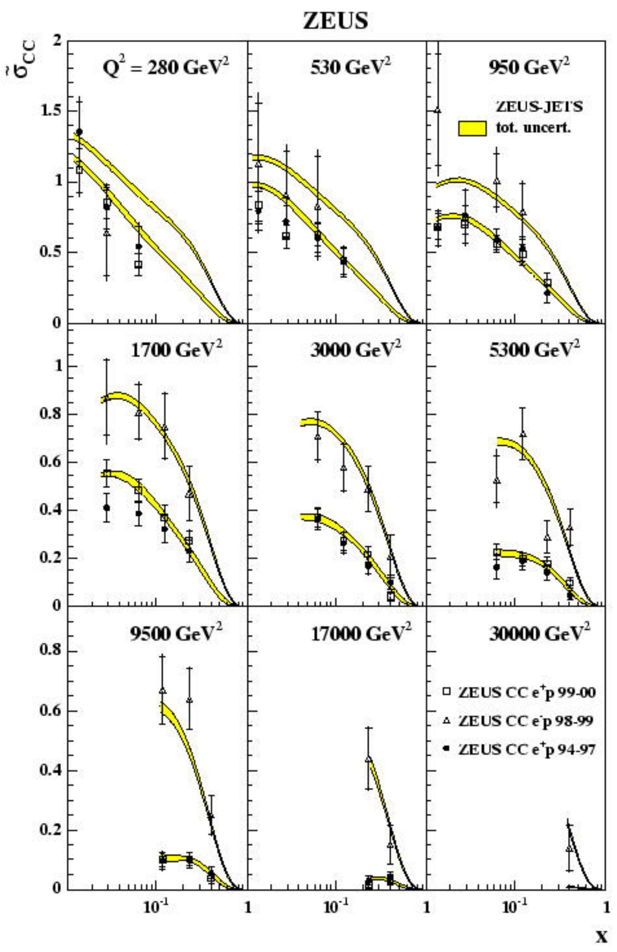
Very good description of the low- medium-Q^2 e^+p NC reduced cross sections

QCD fit results: high-Q^2 NC and CC

NC:



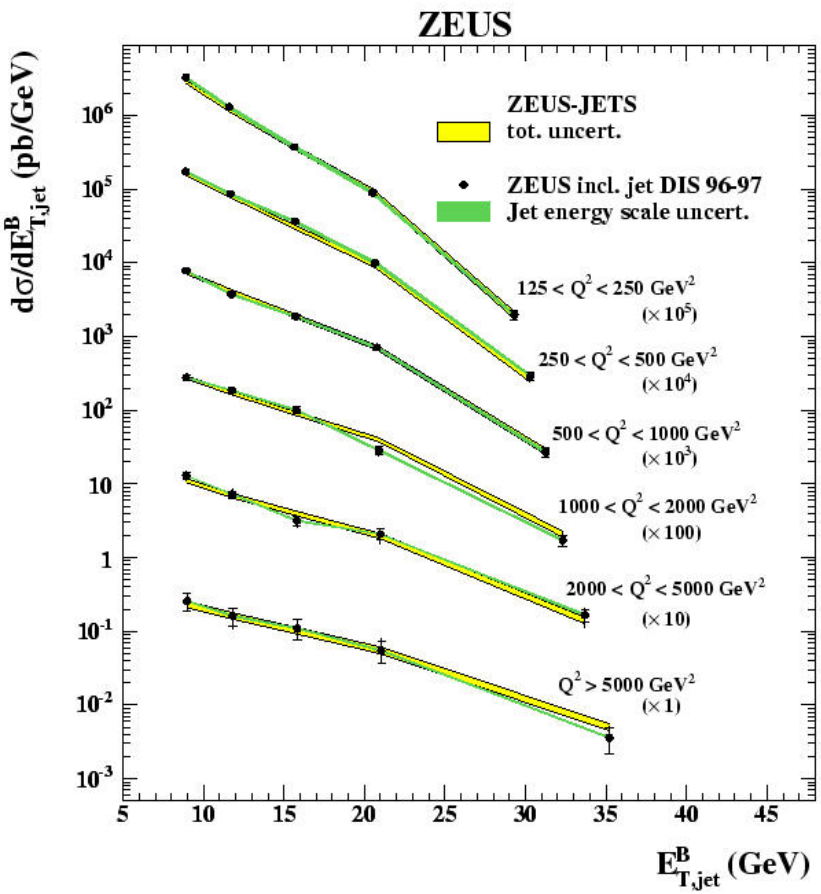
CC:



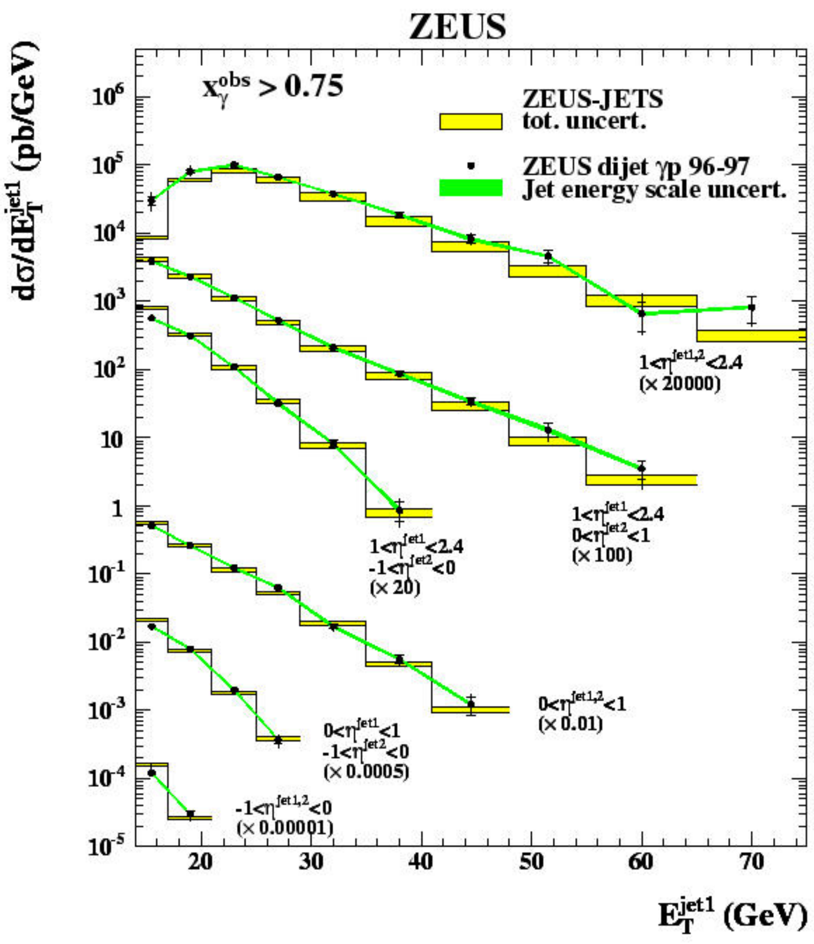
Good description - still limited by statistics => HERAII

QCD fit results: Jet cross sections

Inclusive jet cross sections in e^+p NC DIS



Dijet cross sections in γp

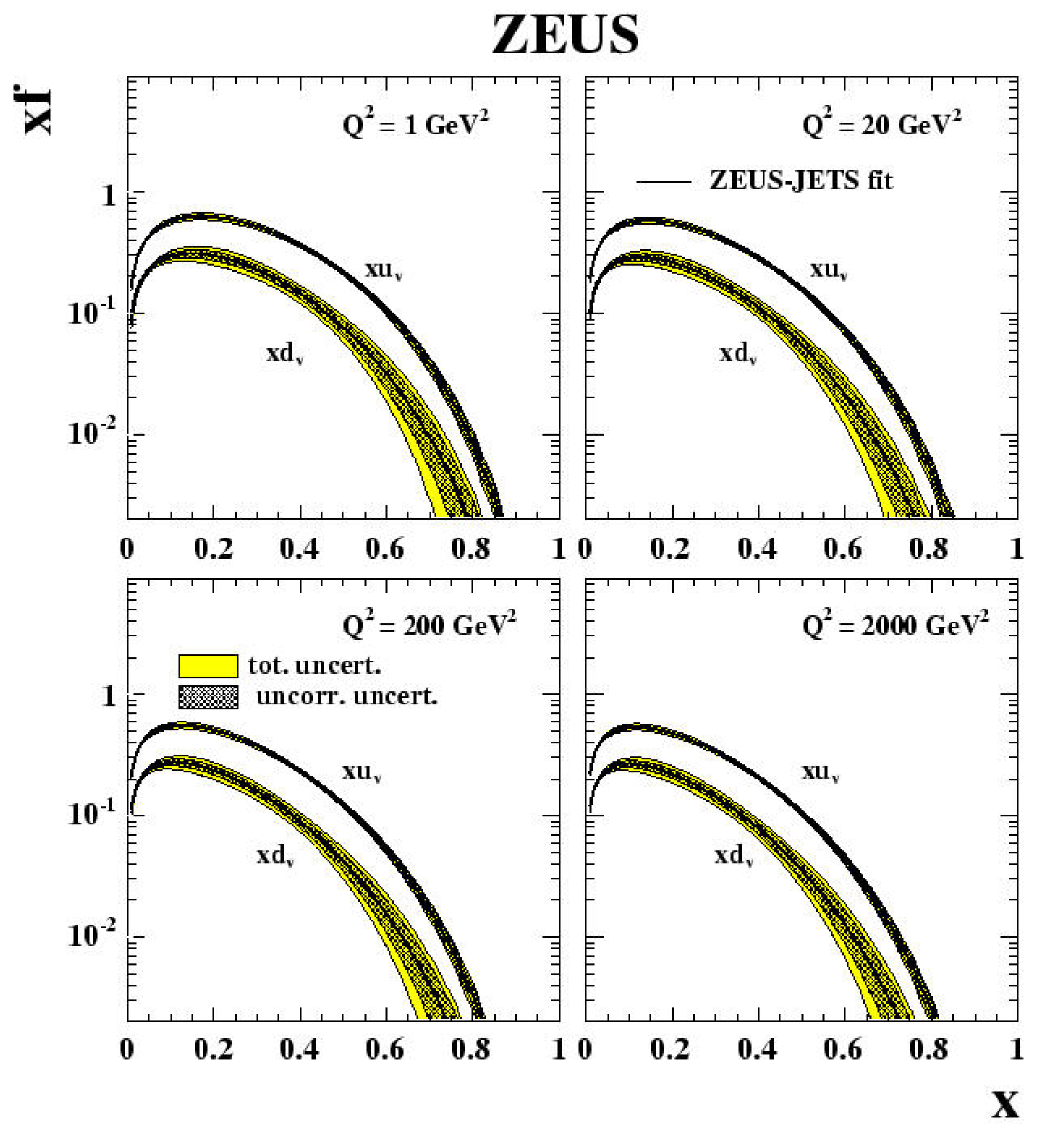


Valence distributions

-At high-x not as well constrained as when including fixed-target data

-…but becoming competitive + being free from heavy-target corrections, isospin-symmetry assumptions etc.

To further improve here we need precision high-Q2 e±p CC/NC data from HERA II

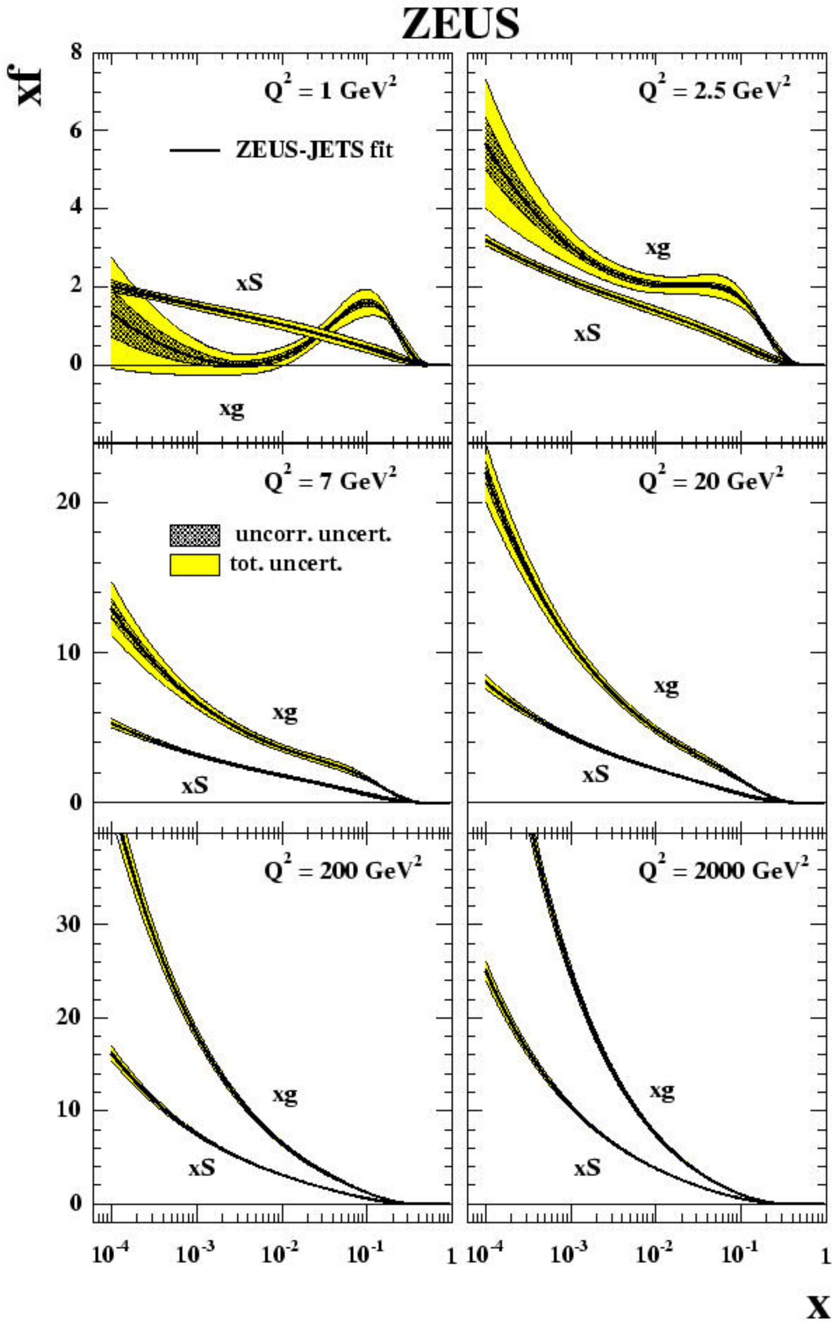


Glue & sea

Both are well determined at low-x ($x<10^{-2}$)

-the sea distribution rises at low-x for all Q^2
-the gluon density becomes valence-like at low Q^2

-The gluon uncertainty has been reduced by the use of the jet data…



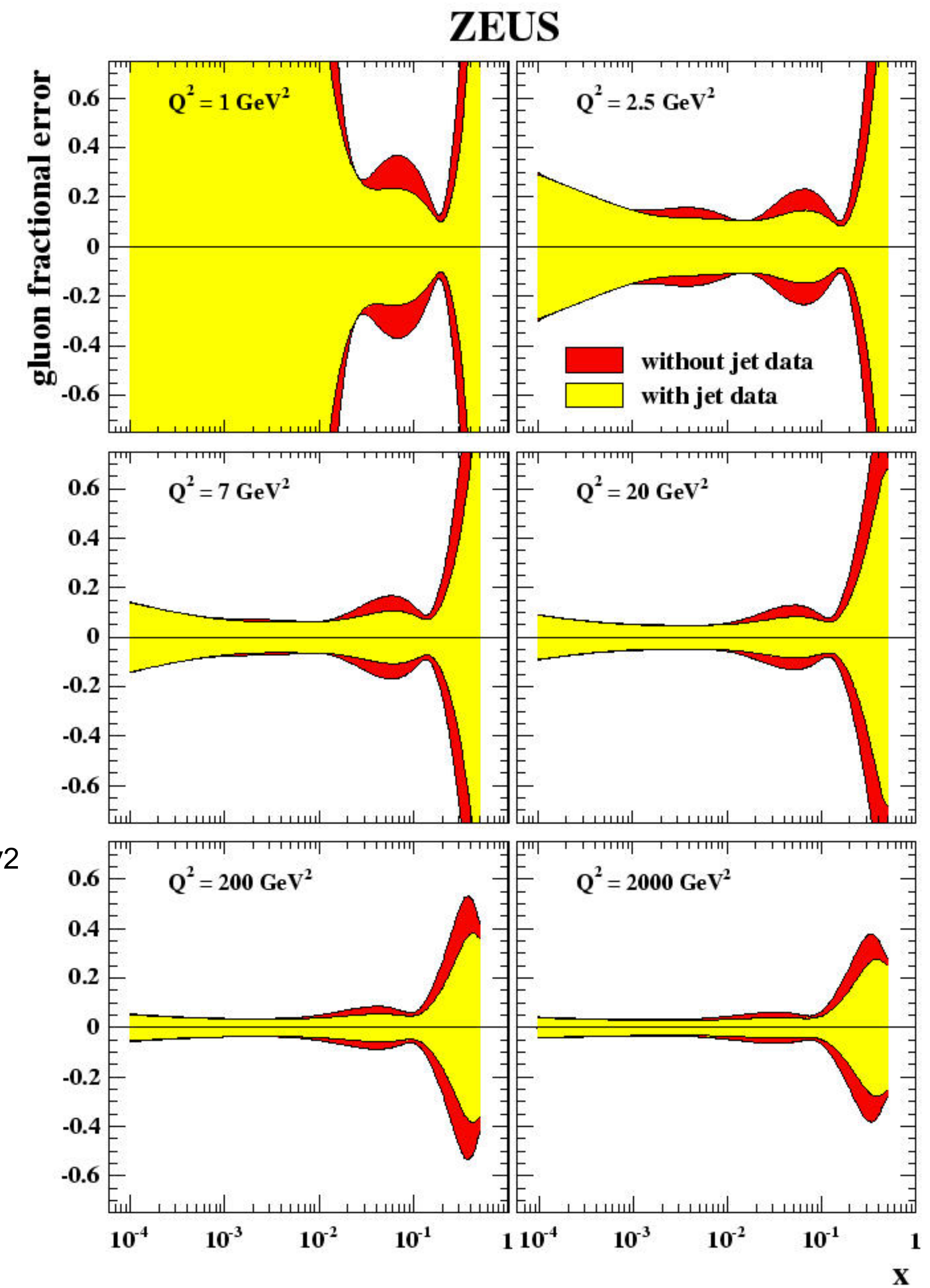
Jet data & gluons

Comparing the gluon distribution obtained from fits with and without jet data:

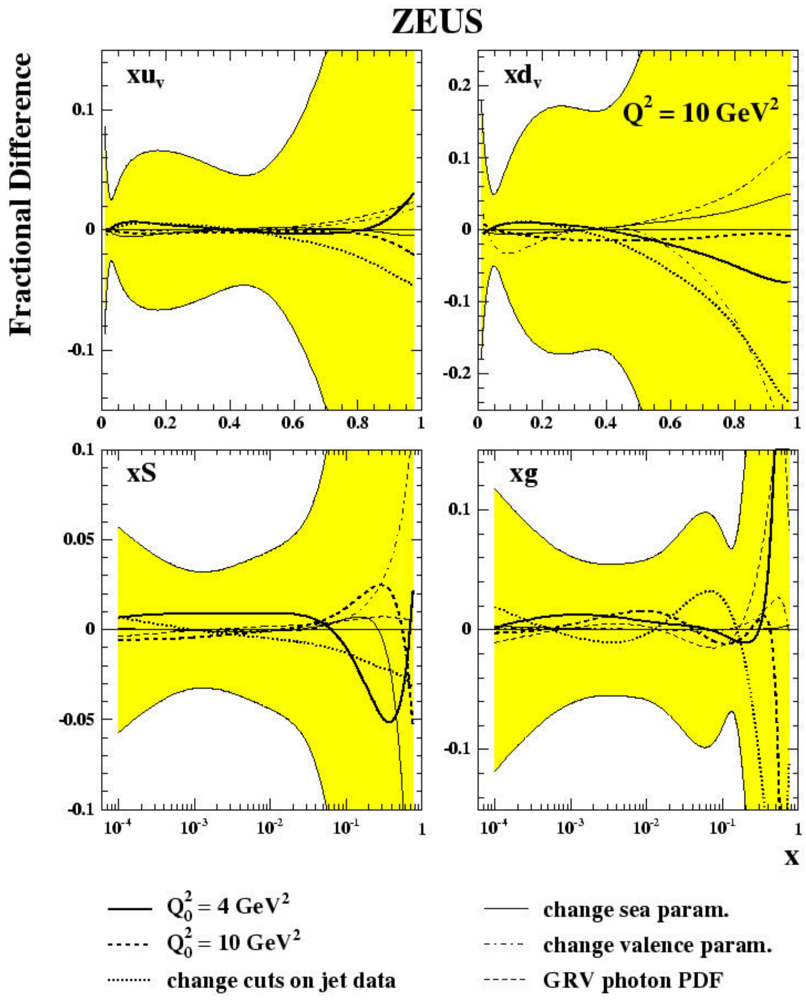
- no significant change of shape: no tension between incl. and jet data

- jet cross sections help in constraining the gluon density in the region:
  $0.01 < x < 0.4$

- Sizeable reduction of the gluon unc:
  e.g. from 17% to 10% at x=0.06 and Q^2=7 GeV^2
  →similar reduction by a factor two in the mid-x region over the full Q^2 region



PDF uncertainties



Checks:

-Value of Q_0^2 varied in the range:
$4 < Q_0^2 < 10$ GeV^2

-Parameterisation of the valence PDFs:
$(1+p_4x) \rightarrow (1+p_4x+p_5\sqrt{x})$

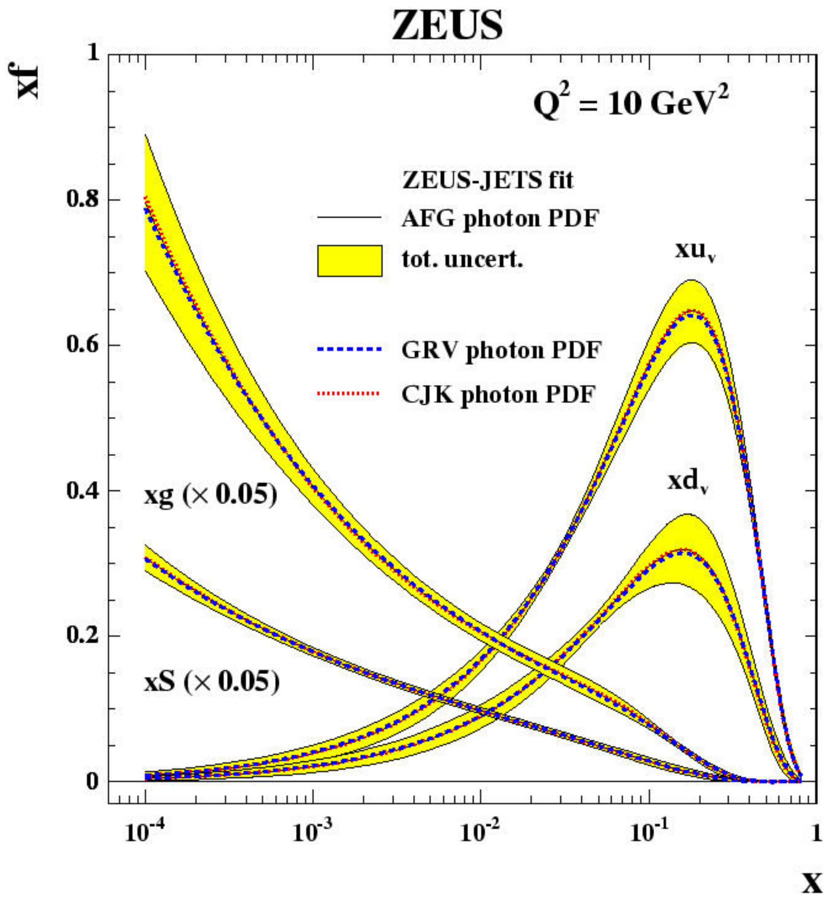
-Tighter cuts on the jet cross sections
$E_{T,jet}$>10 GeV (DIS) , $E_{T,jet}$>17 GeV(γ-p)

-Hadronisation corrections

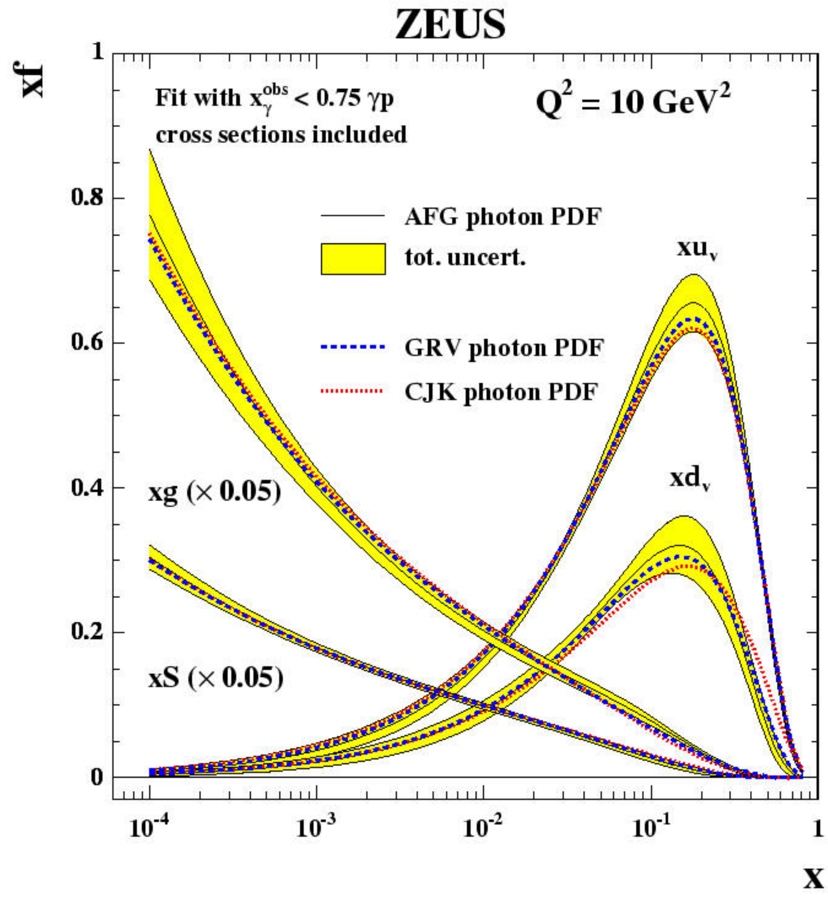
-Photon PDFs

In general effects smaller than the experimental uncertainties

Photon PDFs

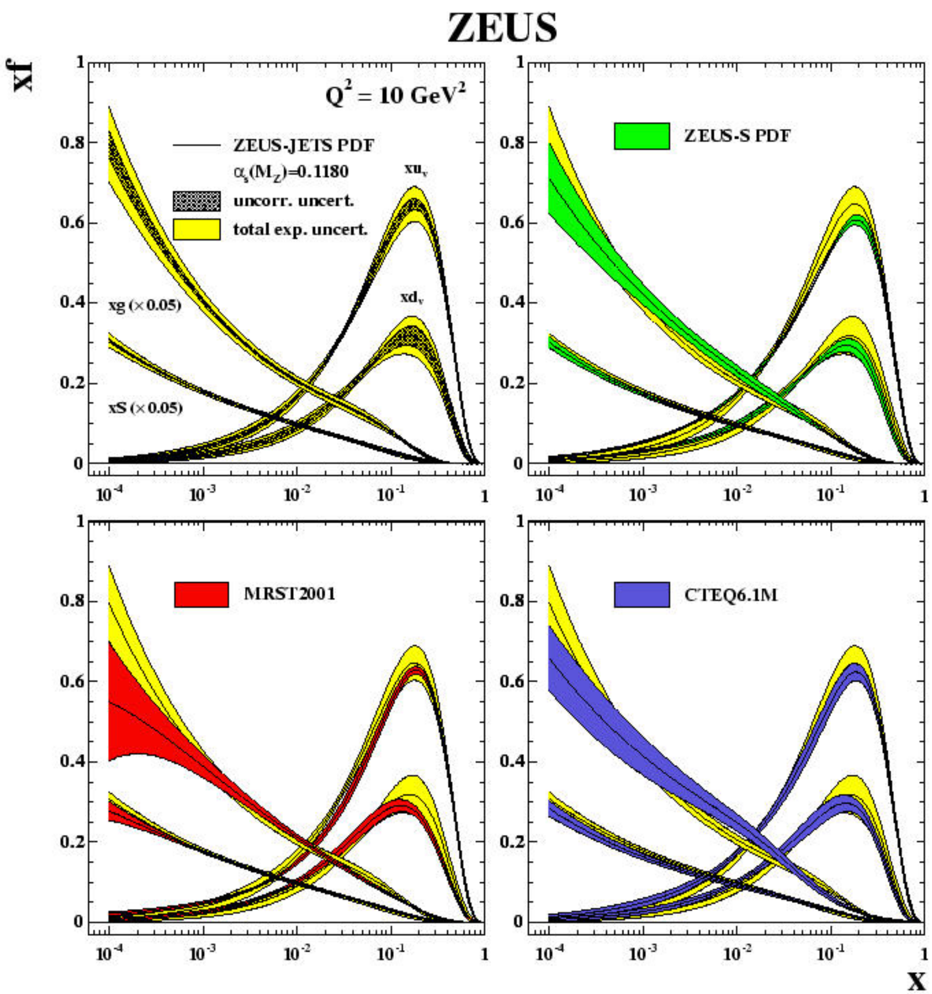


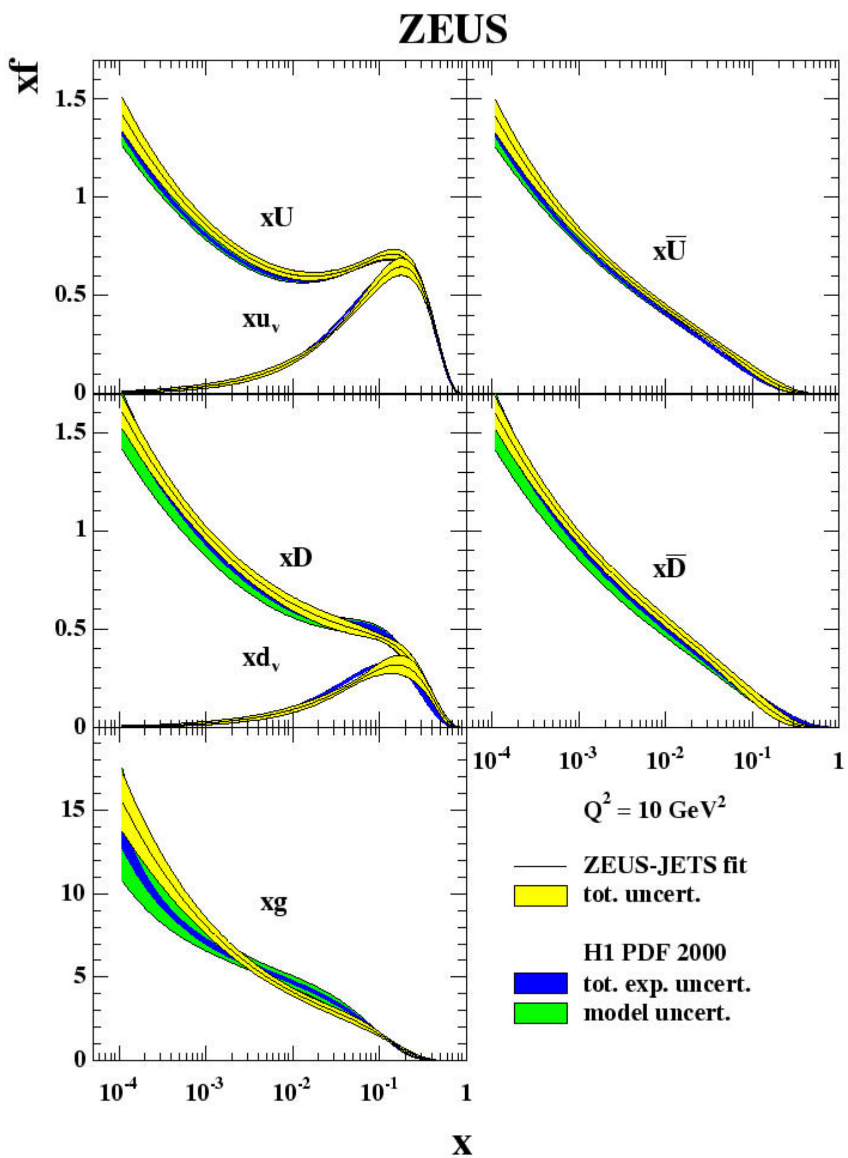
Sensitivity to different photon PDFs (direct-enriched component)



Including the resolved component- some sensitivity to photon PDFs

Comparing PDFs





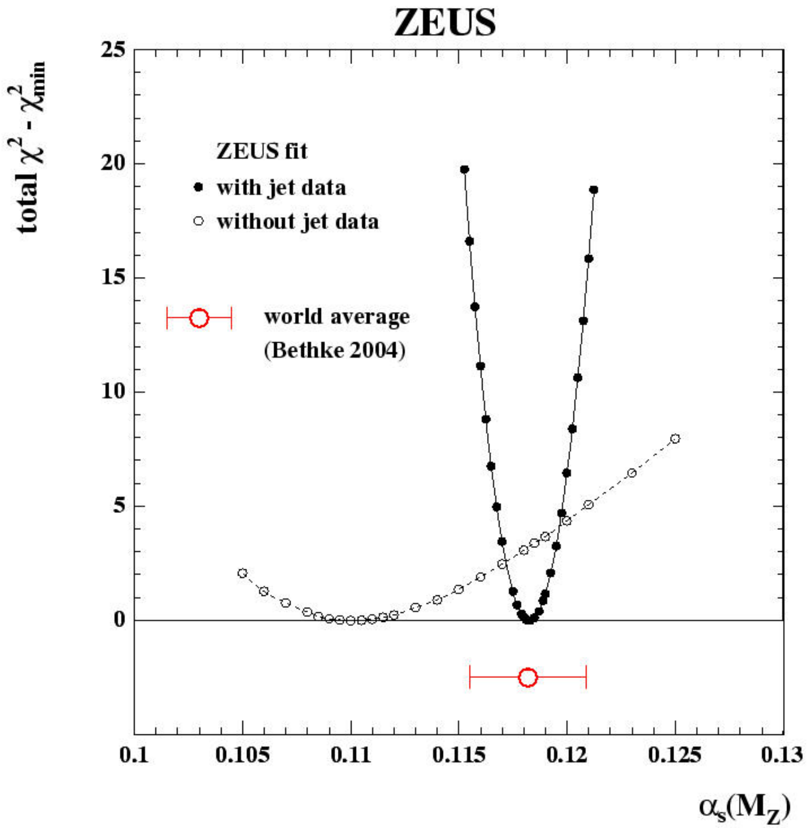
Compatible with ZEUS-S/MRST2001/CTEQ6.1M …and H1

Determination of $\alpha_s(M_Z)$

- Simultaneous determination of PDFs and α_s (free parameter) from ZEUS data alone

- Inclusion of jet data greatly improves the determination of α_s =>

- Exctracted value:



$\alpha_s(M_Z) = 0.1183 \pm 0.0007(\text{uncor.}) \pm 0.0027(\text{corr.}) \pm 0.0008(\text{model})$

The theoretical uncertainty due to terms beyond NLO is : $\Delta\alpha_s(\text{th}) = \pm 0.0050$
(limited by theory => need NNLO jet calculations,
NNLO is ready for the rest of the fit)

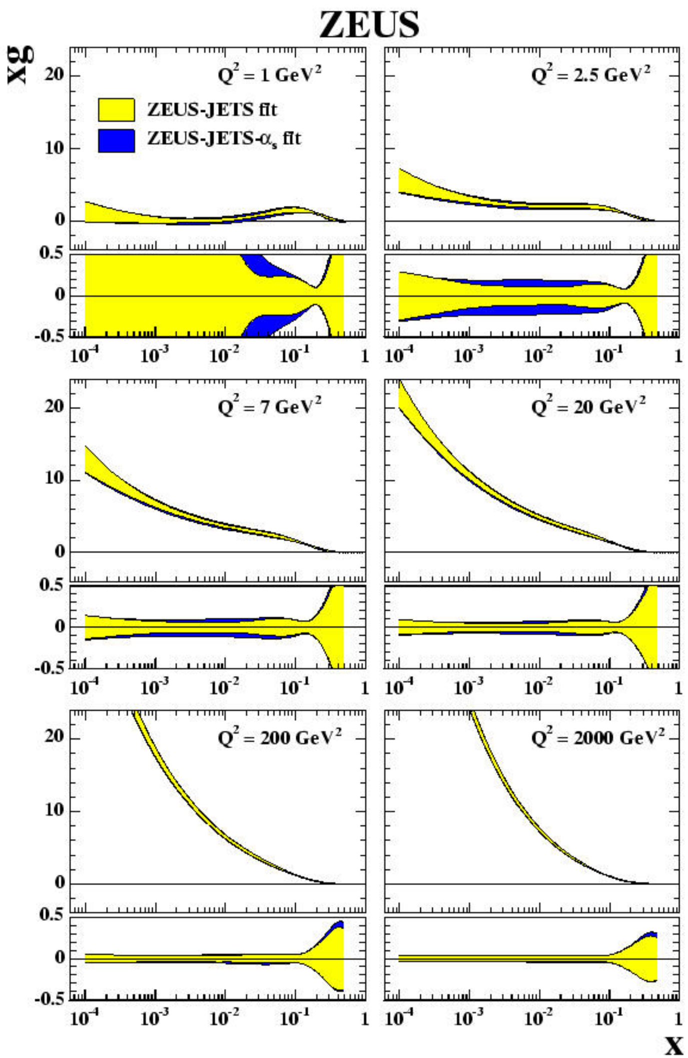
In agreement with the world average $\alpha_s(M_Z) = 0.1182 \pm 0.0027$ (Bethke,2004)

PDFs with α_s free

The extracted $\alpha_s(M_Z)$ value is very close to the fixed value, 0.118, used in the ZEUS-JET fit

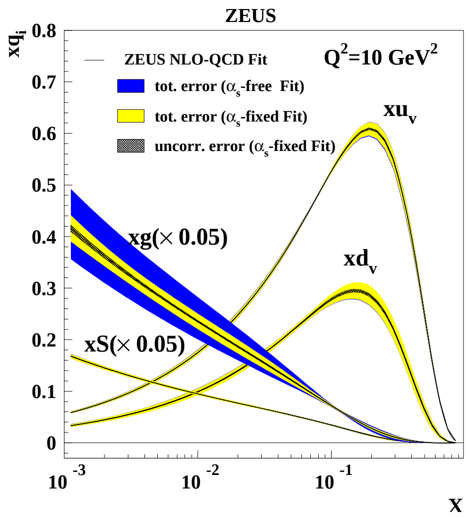
=> there are no significant changes in the central values of the PDFs parameters

Uncertainties:
- The valence and sea unc. are unaffected
- The gluon unc. increases somewhat in the low-Q^2 region



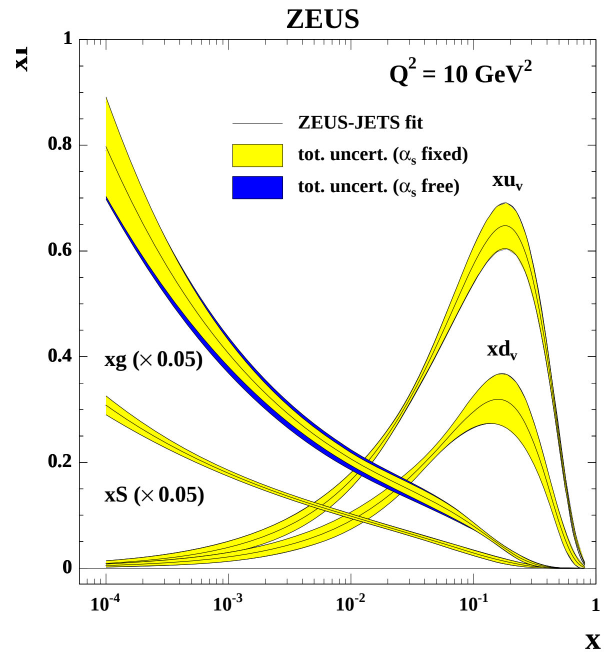
Before jets

ZEUS-S-α_s global fit



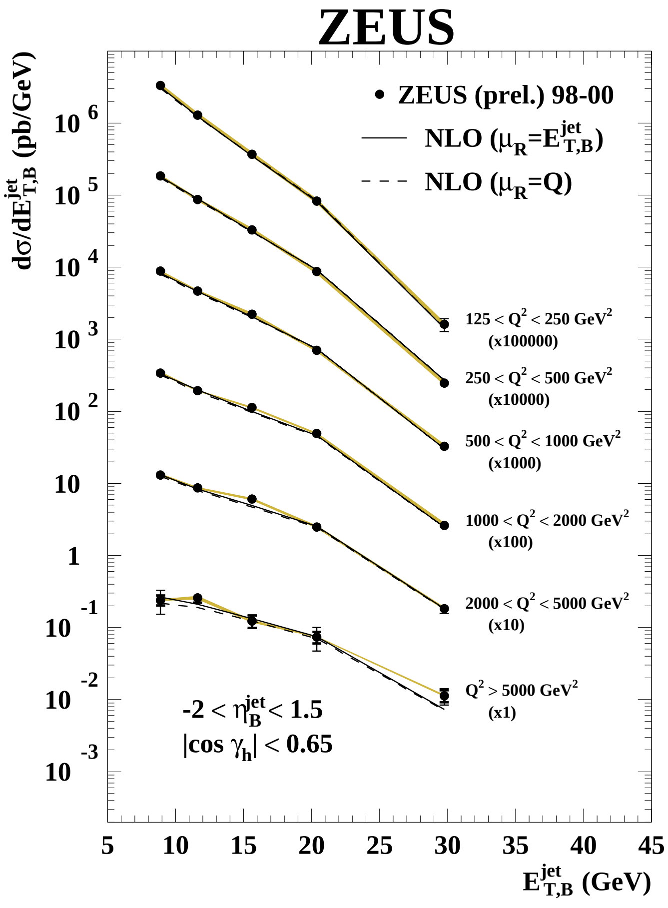
After jets

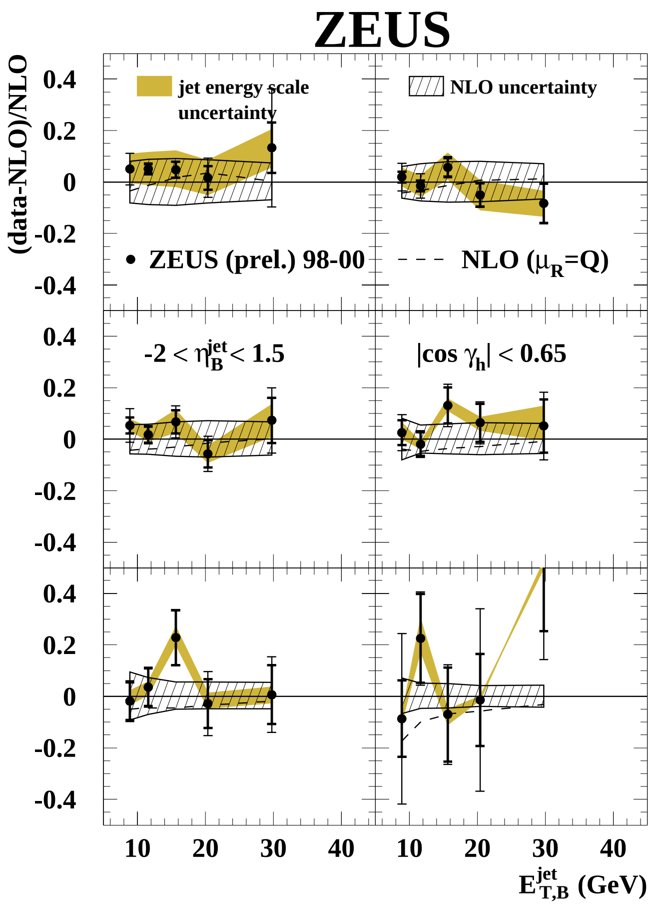
ZEUS-JETS-α_s fit



The contribution of the uncertainty on $\alpha_s(M_Z)$ to the uncertainty on the PDFs is much reduced

Now there are new data which could be included in PDF fits



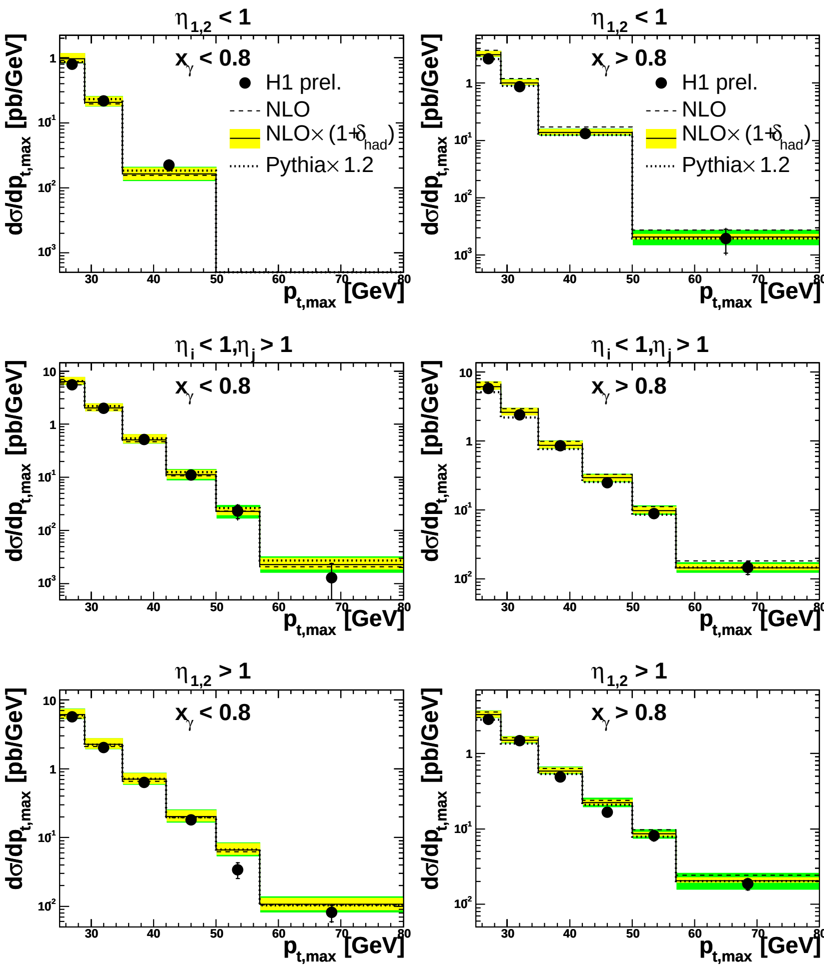


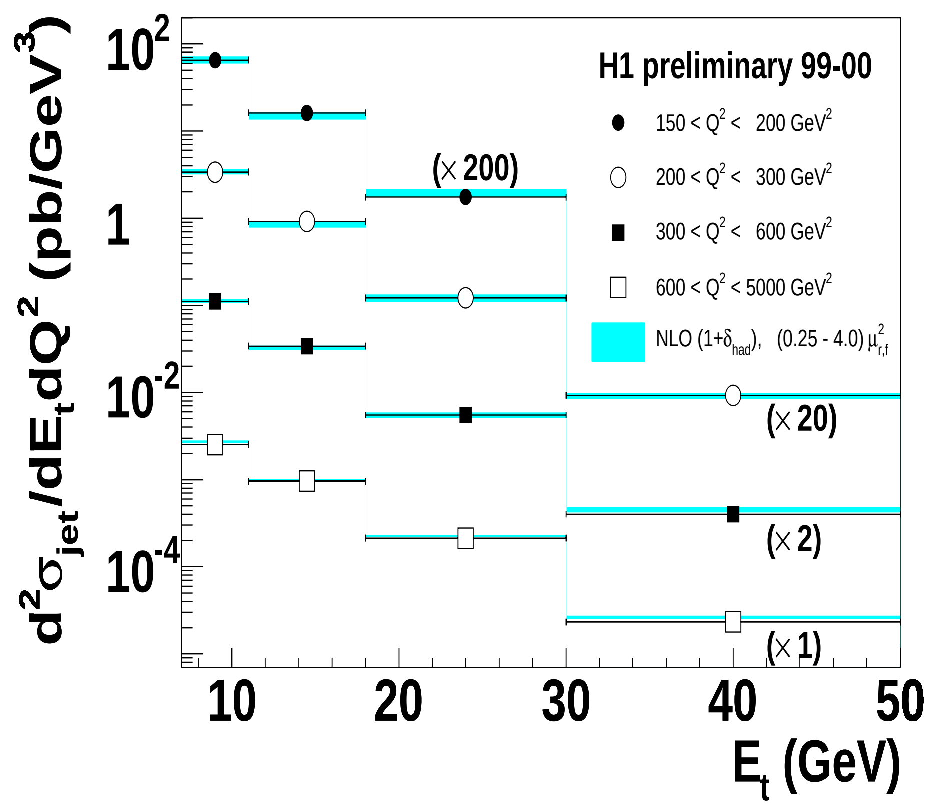
ZEUS Inclusive jet production in NC DIS **HEP 2005-375**

H1 photoproduction di-jets

HEP 2005 paper 680

H1 Inclusive jet production in NC DIS
HEP-2005 paper 629





What is the possible impact of HERA –II data on PDF fits ?

- under currently planned running scenarios hep-ph/0509220

Valence	**High Q^2 inclusive NC/CC $e^{\pm}$ cross sections**
Sea	**Low-x from inclusive NC DIS** **High-x ?**
Gluon	**Low-x from HERA $dF_2/d\ln Q^2$** **Mid-to-high-x from HERA jet data**

More statistics

More statistics and optimized cross-sections?

Currently ~96 pb^{-1} of e+ p NC and CC data –assume 350 pb^{-1}

Currently ~16 pb^{-1} of e- p NC and CC data – assume 350 pb^{-1}

Currently ~37 pb^{-1} of jet data –inclusive DIS and γ-p dijets – assume 500 pb^{-1}

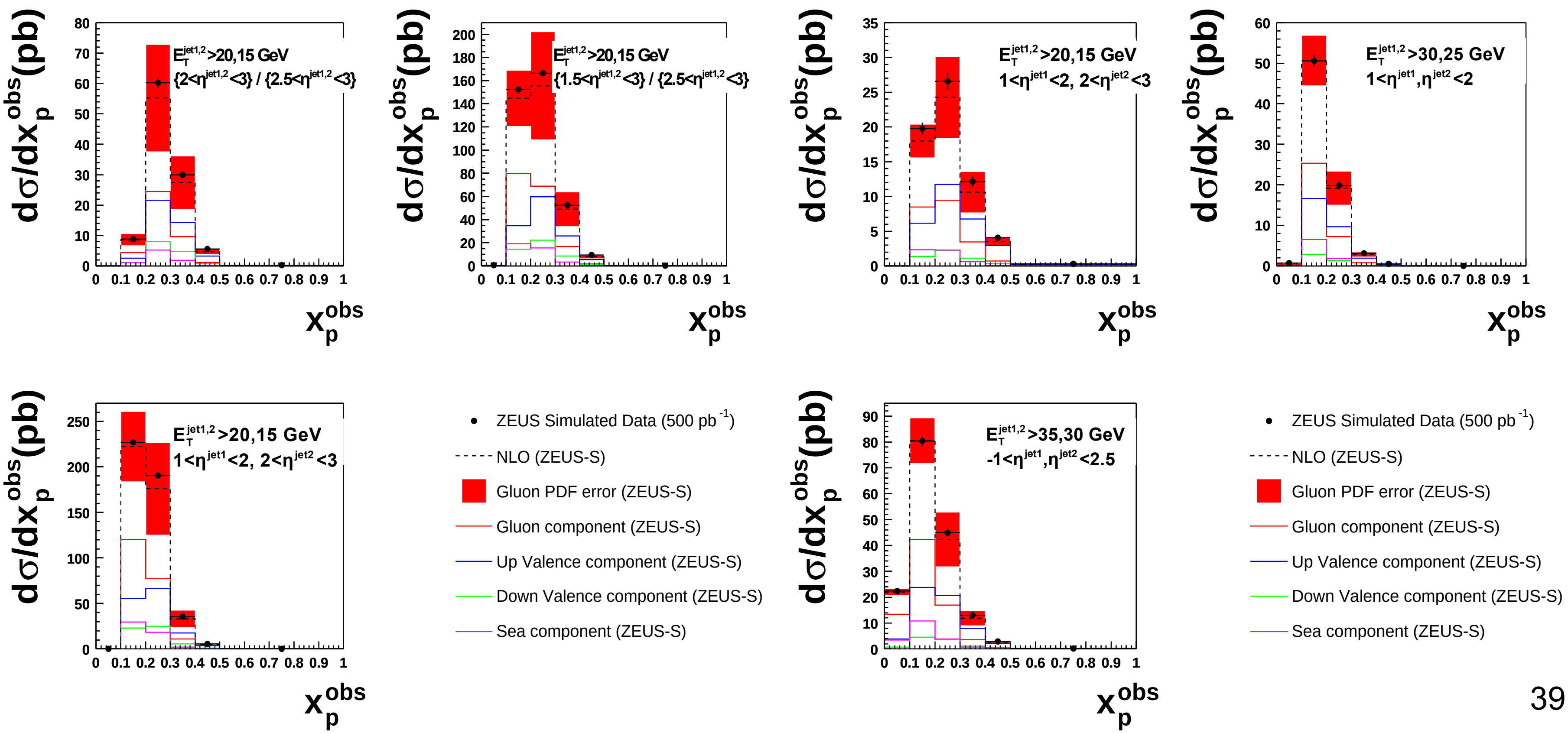
Scale statistical errors from current data- assume systematic errors remain the same

Assume the use of optimised γ-p dijet cross-sections

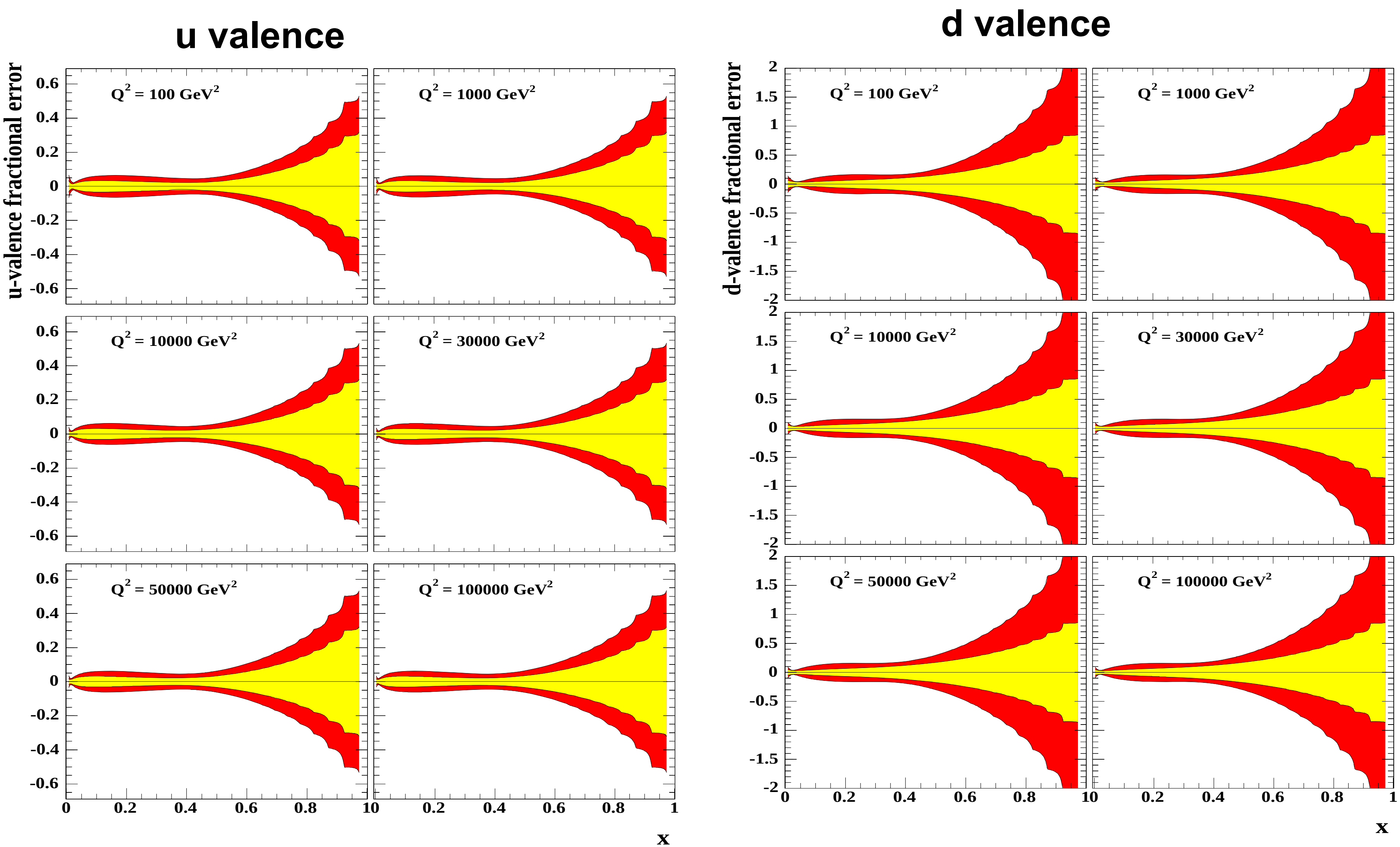
Optimised jet cross-sections

- **Measure jet cross sections in kinematic regions “optimised” for sensitivity to gluon**
  - ongoing ZEUS study: dijets in photoproduction ($Q^2 < 1$ GeV^2)
  - **data simulated using NLO QCD (Frixione-Ridolfi) and CTEQ5M1 proton PDF (500 pb^{-1})**

resolved-photon enhanced: $x_\gamma^{OBS} < 0.75$ **direct-photon enhanced: $x_\gamma^{OBS} > 0.75$**



HERA-II projected fit

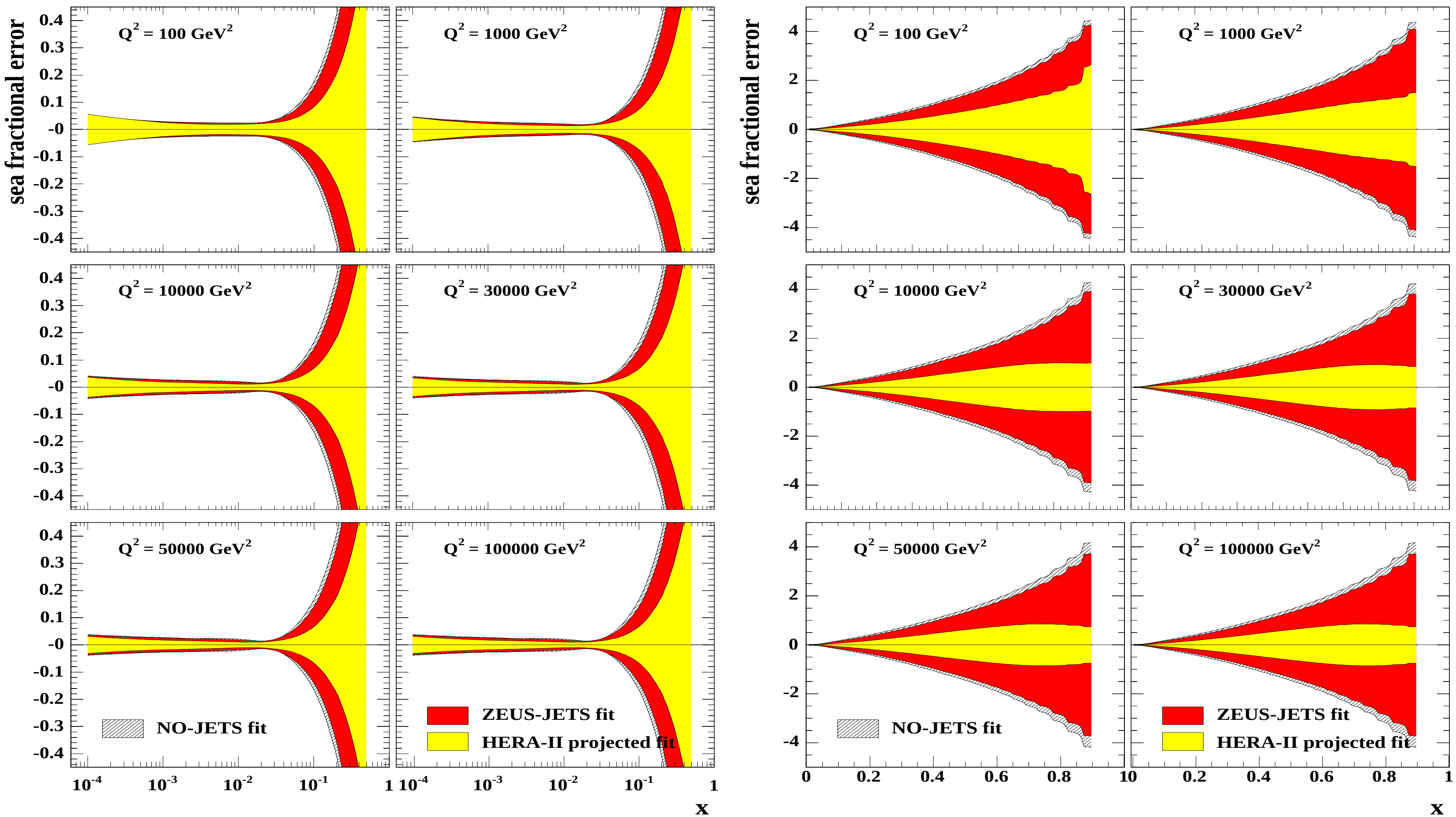


Fractional uncertainties on u and d valence improved by more statistics

HERA-II projected fit

Sea quark uncertainties

log-x scale (low-x region) **linear-x scale (high-x region)**

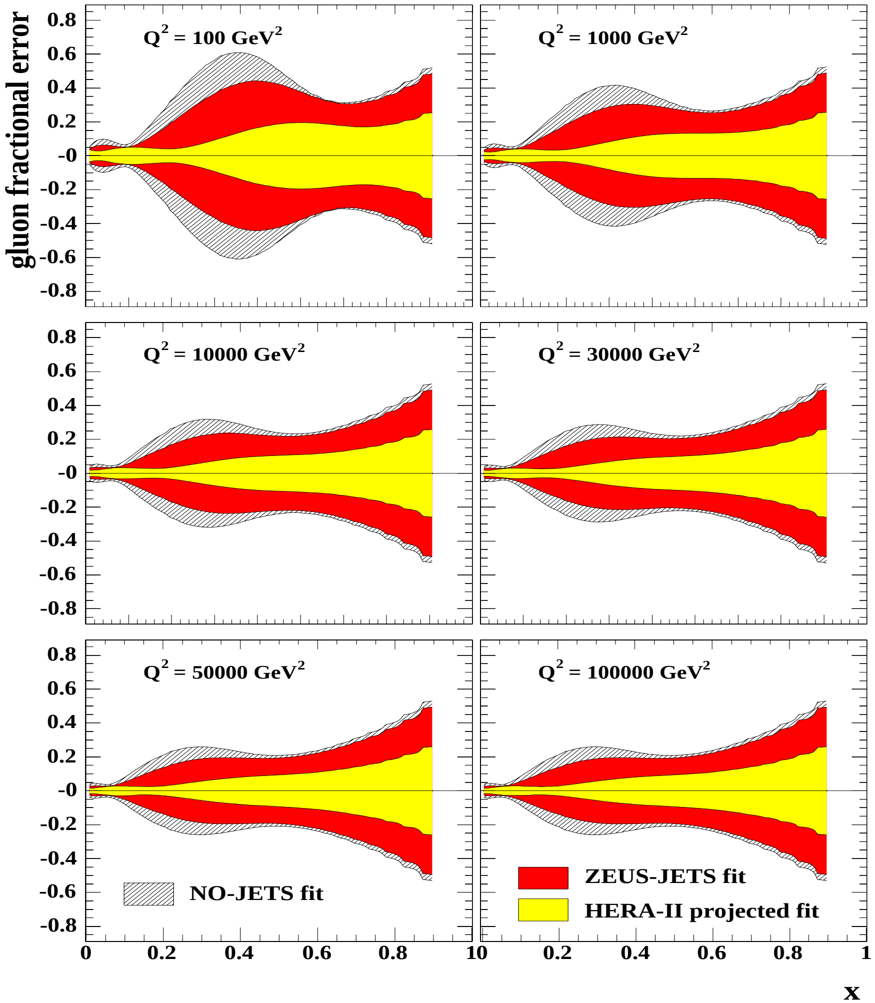


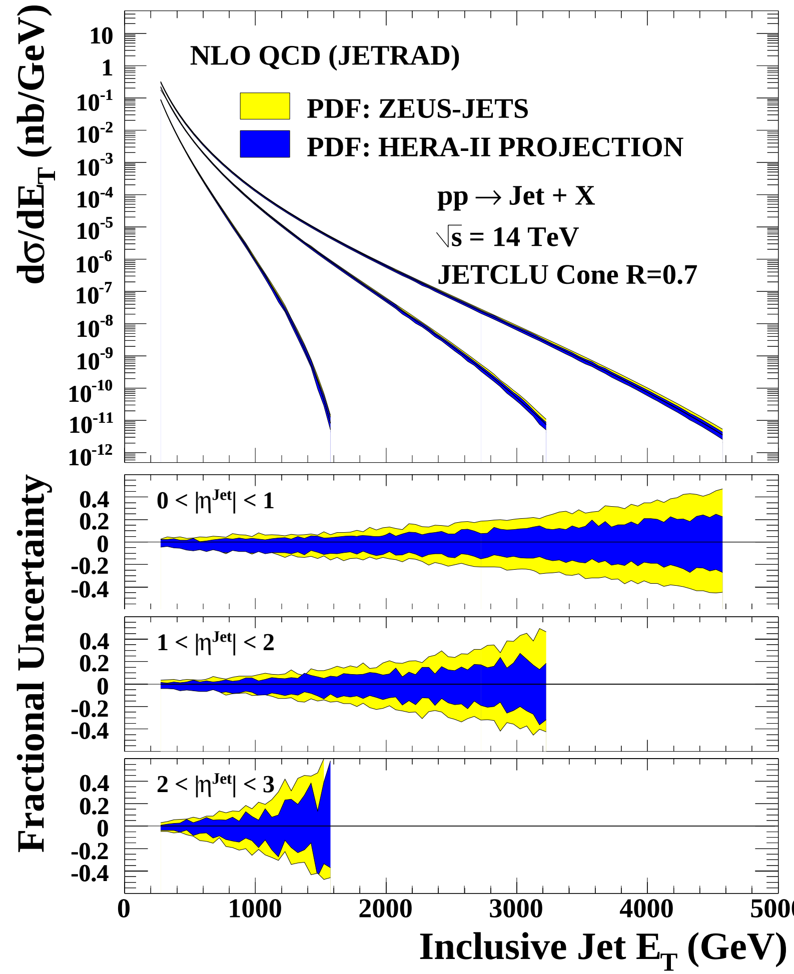
- uncertainties on sea-quark distribution significantly reduced at high-x

HERA-II projected fit

Gluon uncertainties

linear-x scale (high-x region)





Reduced uncertainties on high-x gluon translate into reduced uncertainties on high E_T jet cross-sections at the LHC

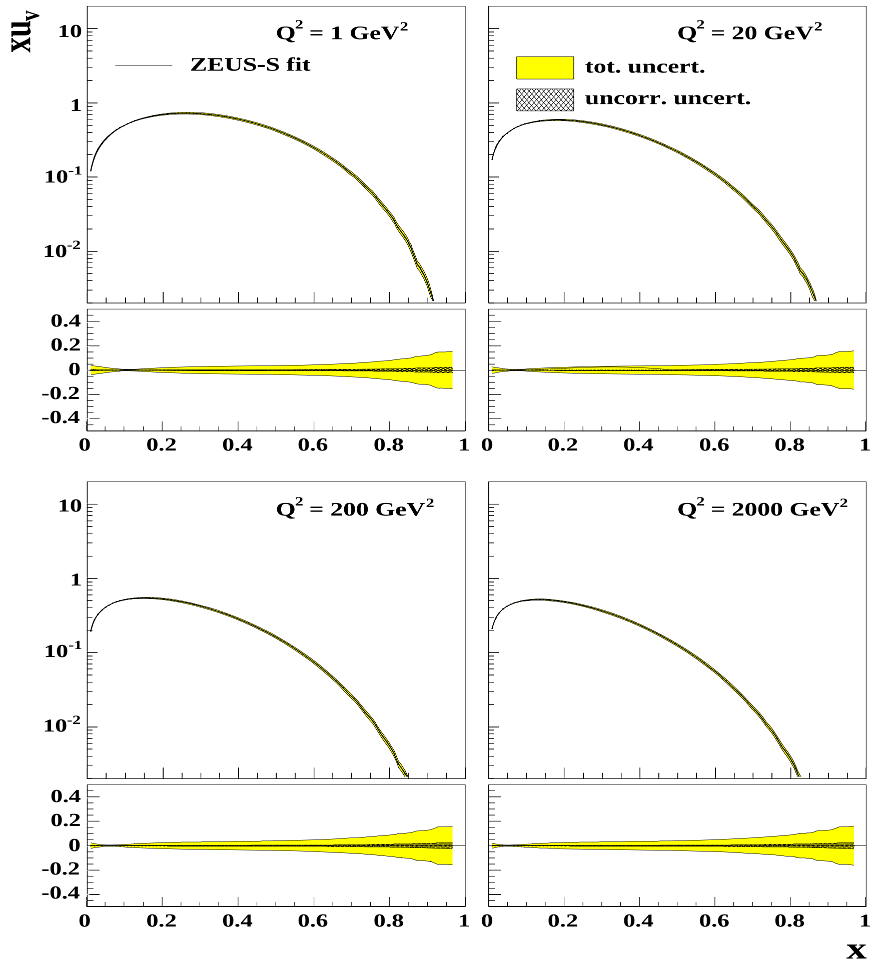
Summary

- Use of jet production data for precision measurements of $\alpha_s(M_Z)$ has yielded the HERA average
$\alpha_s(M_Z) = 0.1186 \pm 0.0011(\text{exp}) \pm 0.0050(\text{th})$
- More results are coming in all the time..it is clear that improved statistics also help to reduced systematics.
- Jet production data clearly establish running $\alpha_s(Q^2)$ within one experiment
- Use of jet production data in PDF fits has now come of age – the simultaneous fit of jet data and inclusive data is a compelling demonstration of QCD factorisation
- The improvement of the precision on the gluon at mid-to high-x has important implications for discovery physics at the LHC
- We look forward to even better results in future

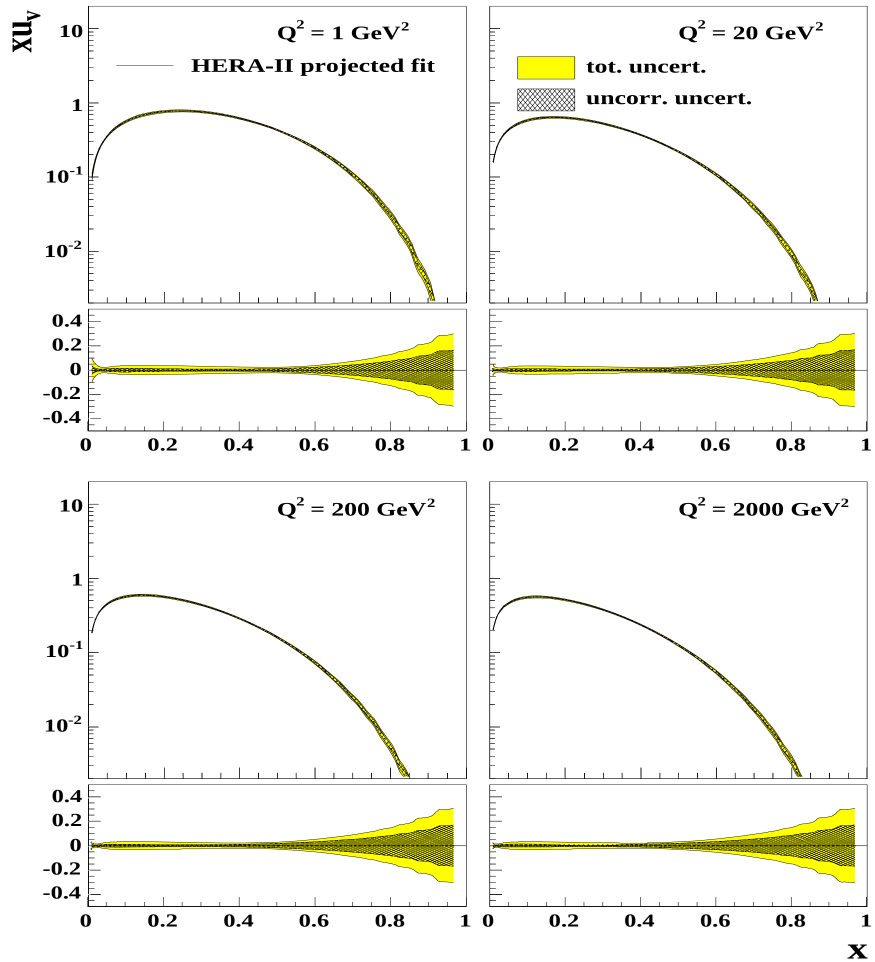
extras

Comparison with global fit (u-val.)

ZEUS-S global PDF

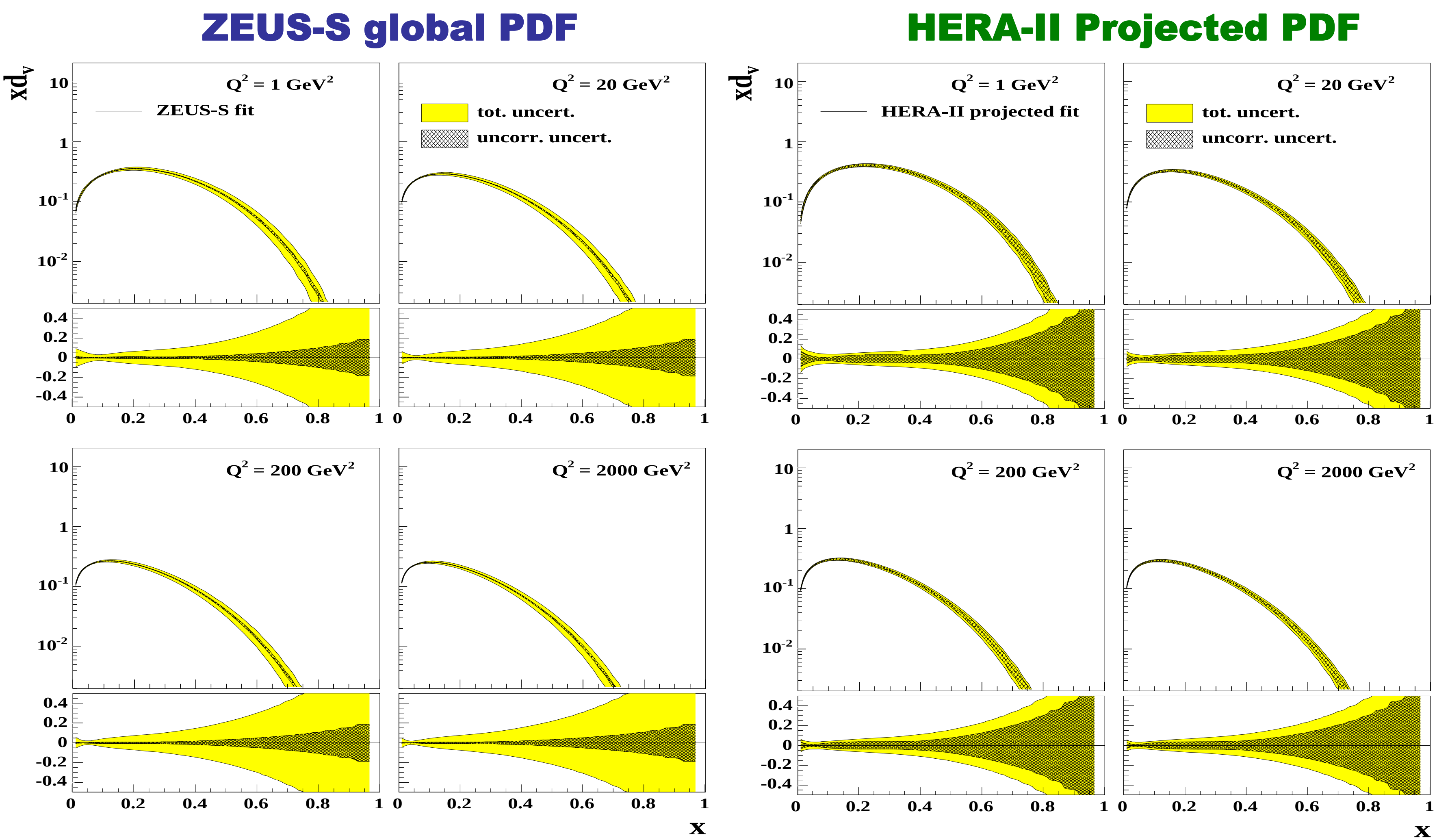


HERA-II Projected PDF



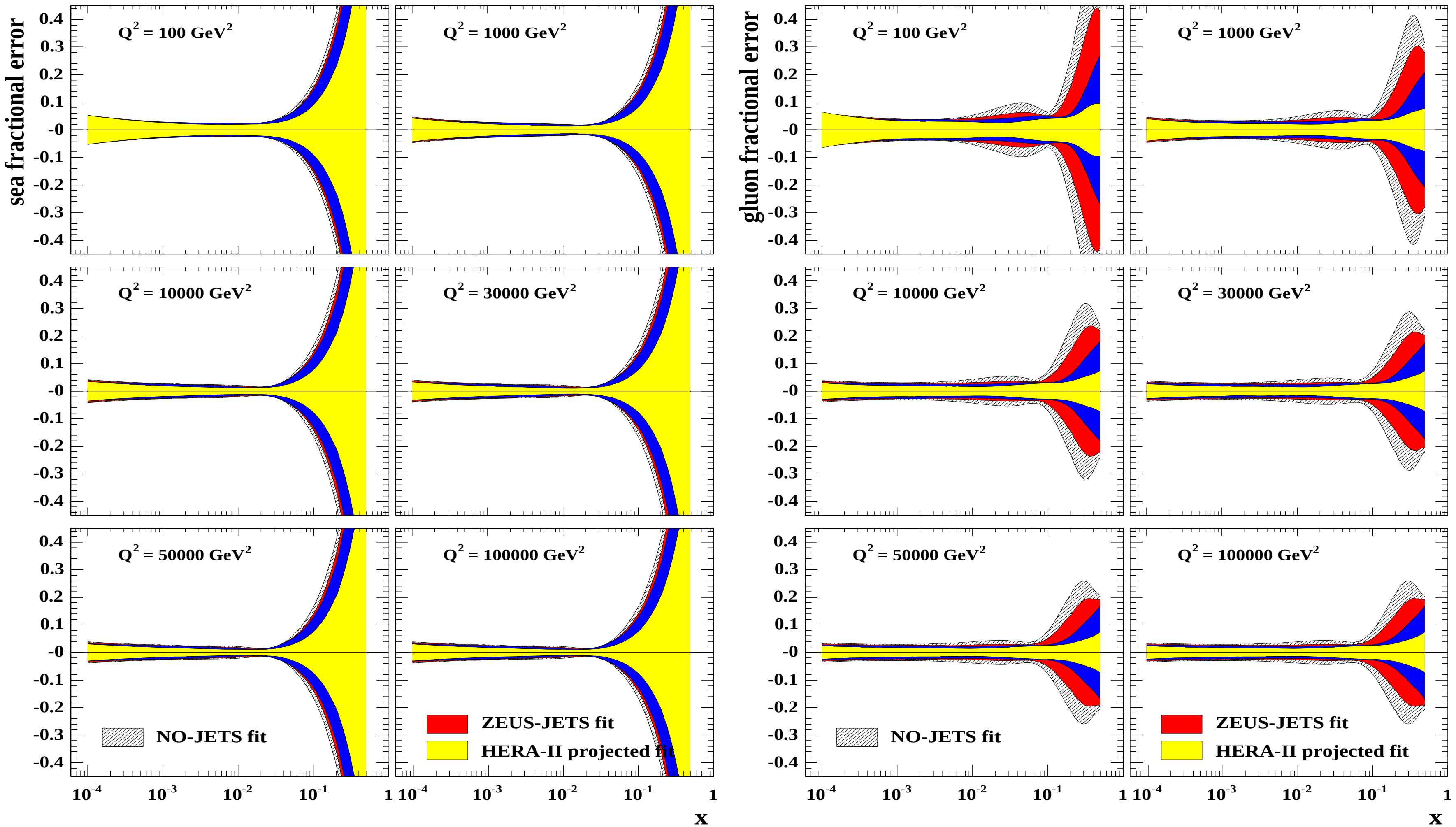
- Uncertainties with full HERA-II inclusive data-set comparable to global fits

Comparison with global fit (d-val.)



- Uncertainties comparable to or better than current global fit

Impact on sea/gluon uncertainties



- blue band: ZEUS-JETS fit + 120 pb^{-1} (HERA-I) optimised jet cross sections only
  - already at HERA-I, optimised jet cross sections would have significant impact on high-x gluon