Highlights from ZEUS

Matthew Wing (UCL)

- **Introduction**
- **Physics at high Q^2**
- **Diffraction and their parton densities**
- **The hadronic final state**
- **Heavy quark production and fragmentation**
- **Conclusion**

Introduction

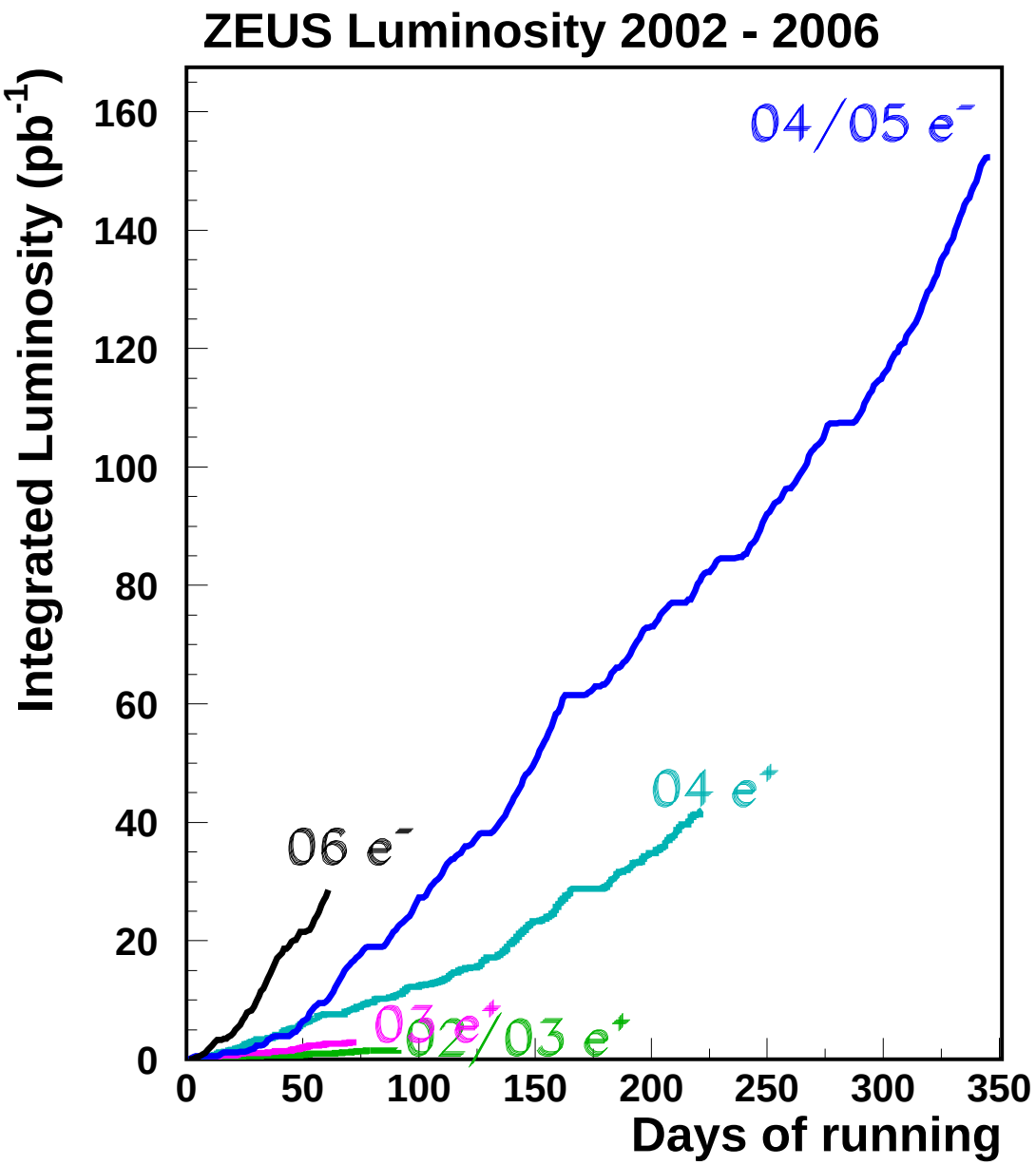
ZEUS has its first paper on HERA II - CC/NC DIS

$\mathcal{L}_{\text{HERA I}} \sim$ **130 pb**$^{-1}$

$\mathcal{L}_{\text{HERA II}} \sim$ **200 pb**$^{-1}$

HERA I data still provides a wealth of results

Significant steps with HERA II data



New results since DIS 2005

High Q^2 and fits

- CC and NC DIS at HERA II: e^+p, e^-p
- Combined EW and QCD fits
- Inclusive jets and dijets in DIS
- Neutral current DIS at high x
- Isolated leptons at high p_T
- Search for gravitino production
- Search for stop production in SUSY

Hadronic final state

- K_s^0 and Λ production
- Proton and anti-deuteron production
- Event shapes in DIS
- Prompt photon production
- Three and four jets in γp
- Angular correlations in three jet DIS
- Subjet rates in DIS

Diffraction

- Rapidity gaps between jets
- Dijets in diffractive DIS
- Diffractive D^* production in γp
- Leading neutrons in DIS and γp
- Large rapidity gaps at high Q^2
- Di-pion production

Heavy quarks

- Di-muon and $D^*\mu$ cross sections
- Charm fragmentation in γp
- Charm jet cross sections in γp
- Inelastic J/ψ production in DIS
- Beauty in DIS and γp at HERA II
- D mesons at HERA II

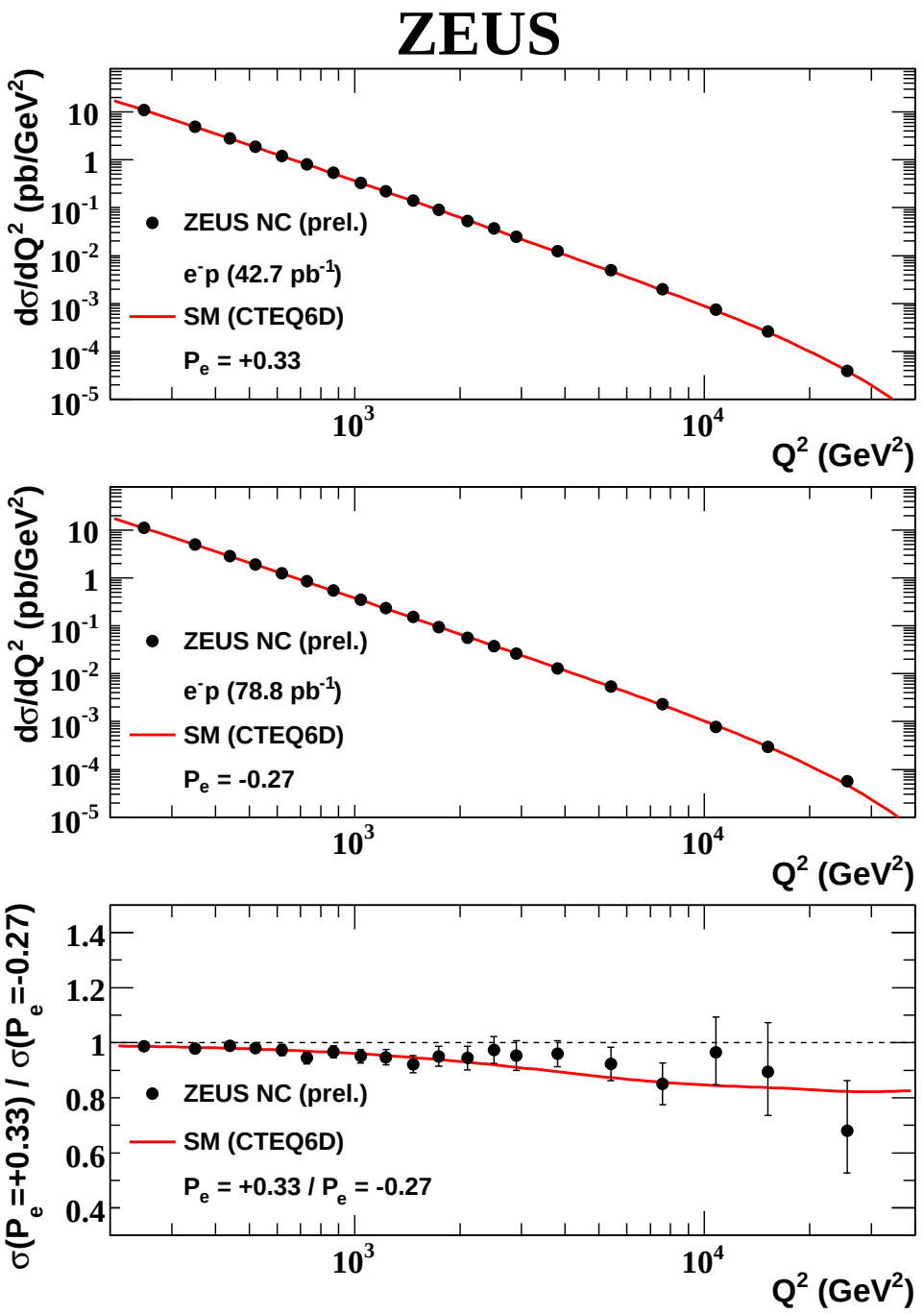
Inclusive DIS cross sections

First HERA II publication: **"Measurement of high-Q^2 deep inelastic scattering cross sections with a longitudinally polarised positron beam at HERA", DESY-06-015.**

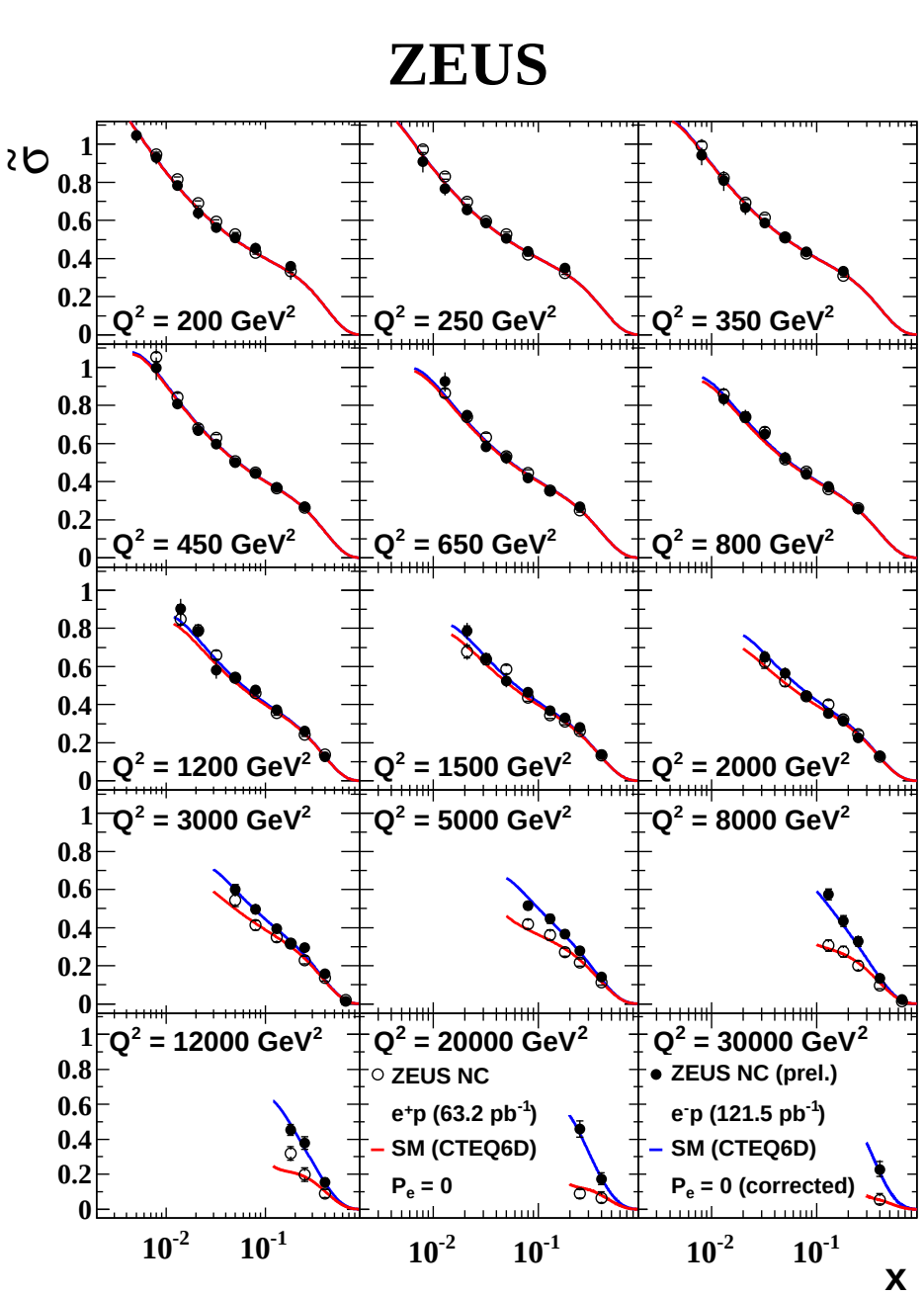
New high Q^2 (CC/NC) cross sections based on all 2005 data, $\mathcal{L}$ = 122 pb^{-1}:

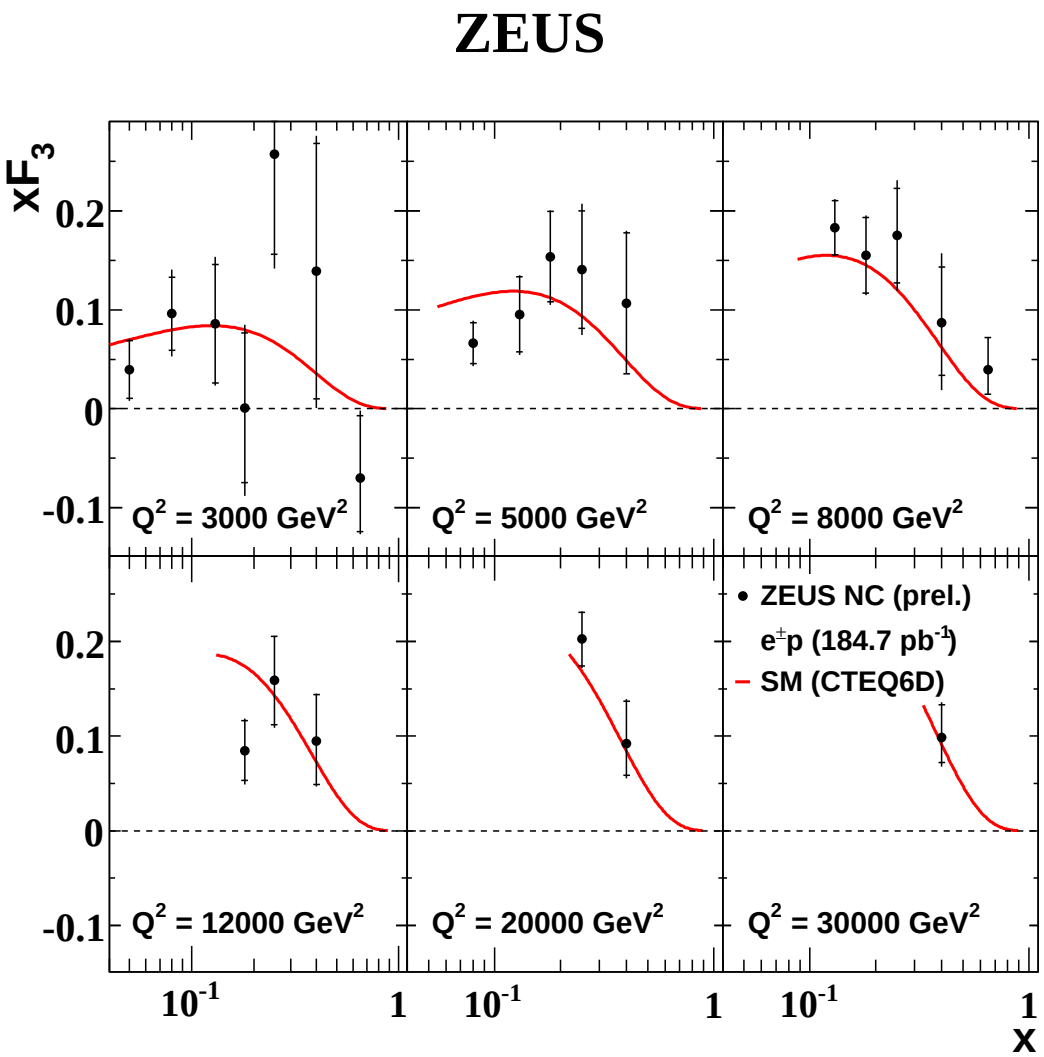
- **$\mathcal{L}$ = 43 pb^{-1}, P_e = 0.33**
- **$\mathcal{L}$ = 79 pb^{-1}, P_e = -0.27**

Now clearly see polarisation effects in NC data as well.



Neutral current cross sections

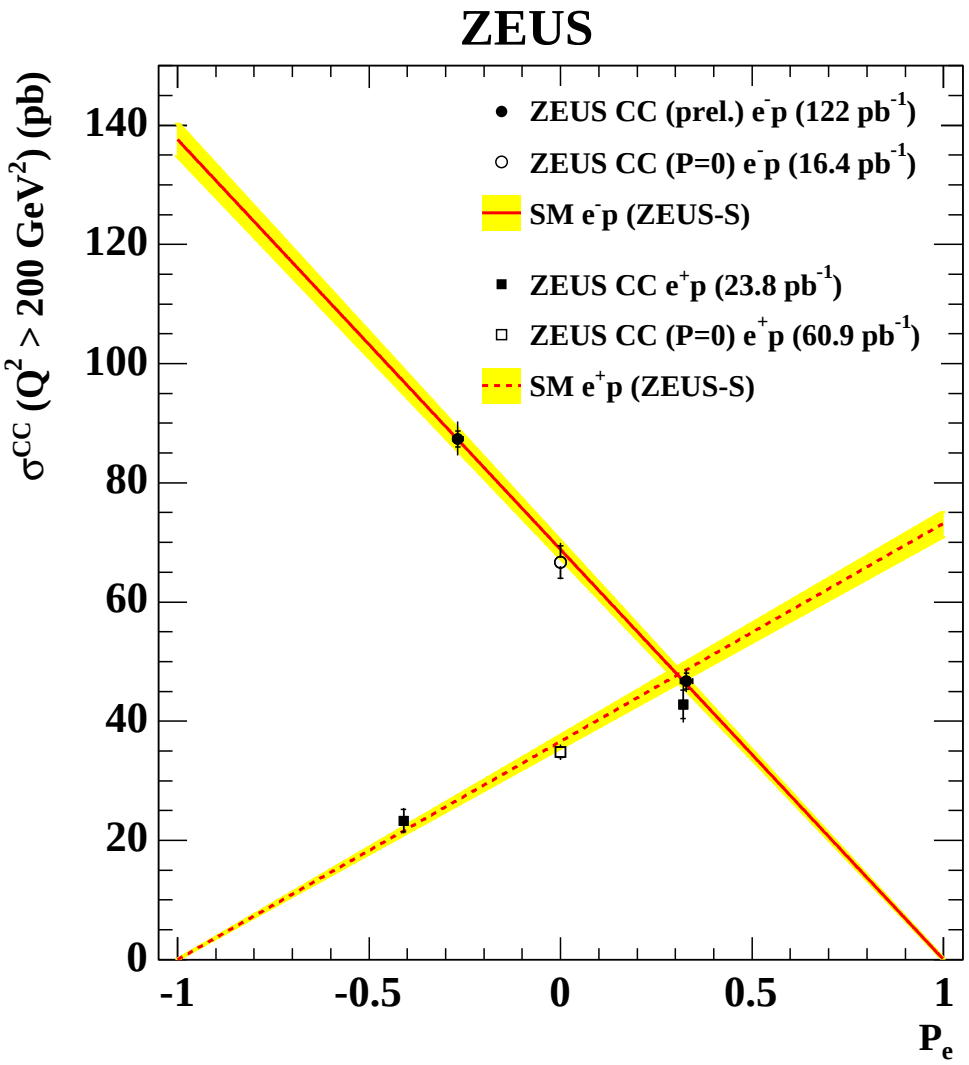


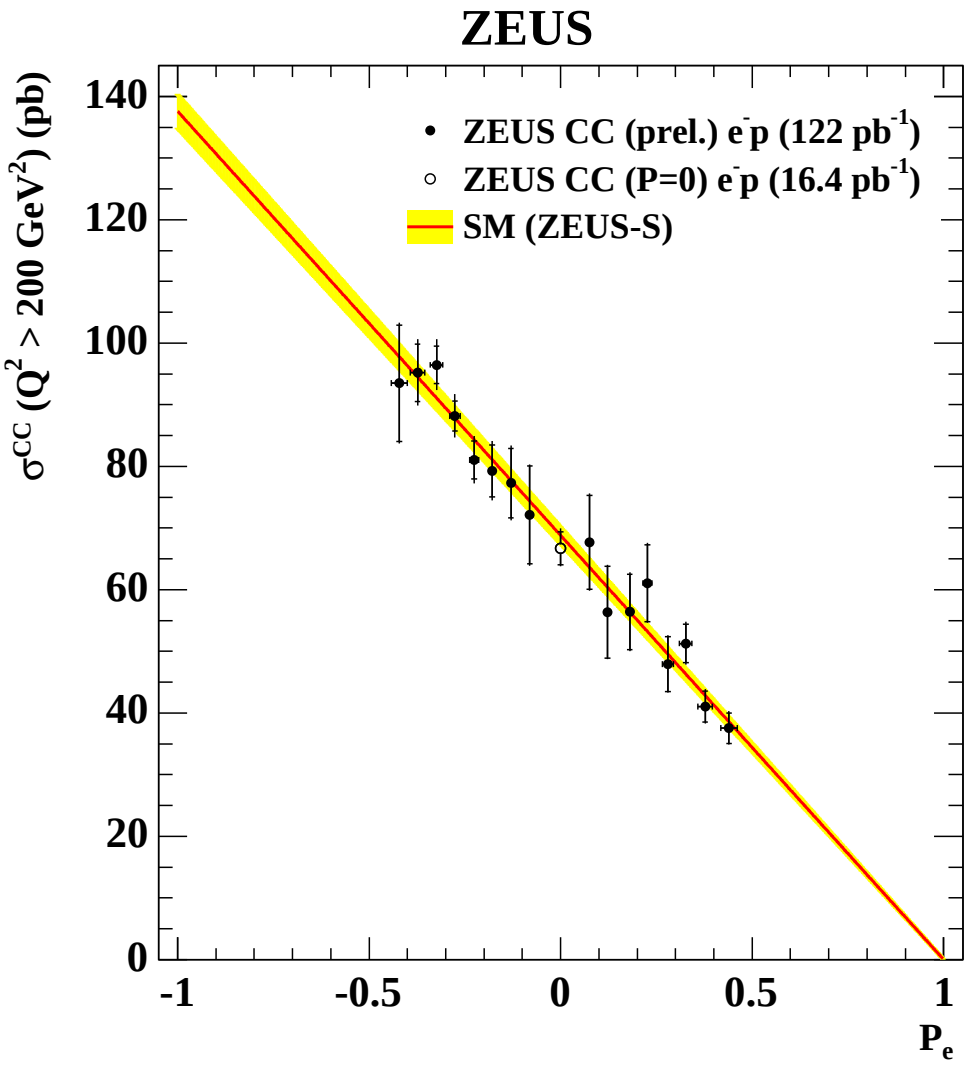


Consistency between data and SM

Still more improvements to come

Charged current cross sections

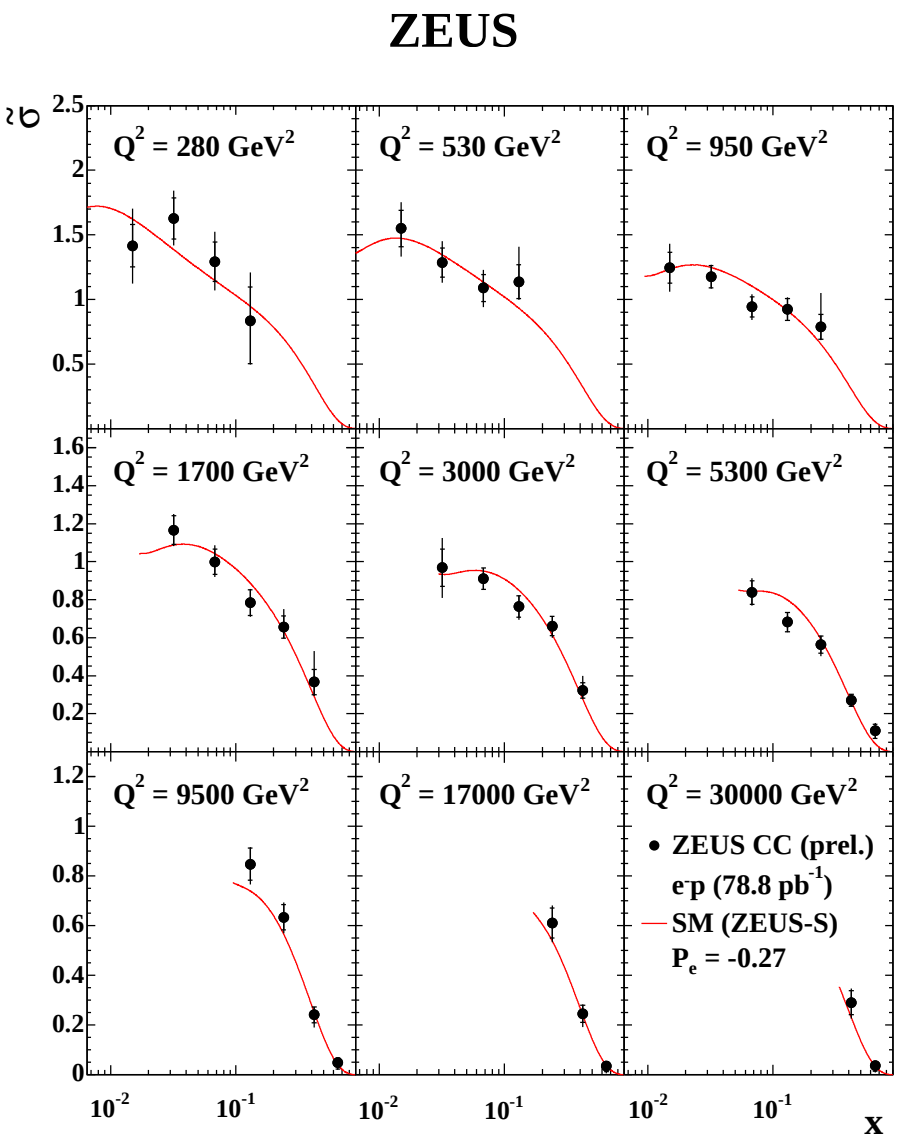


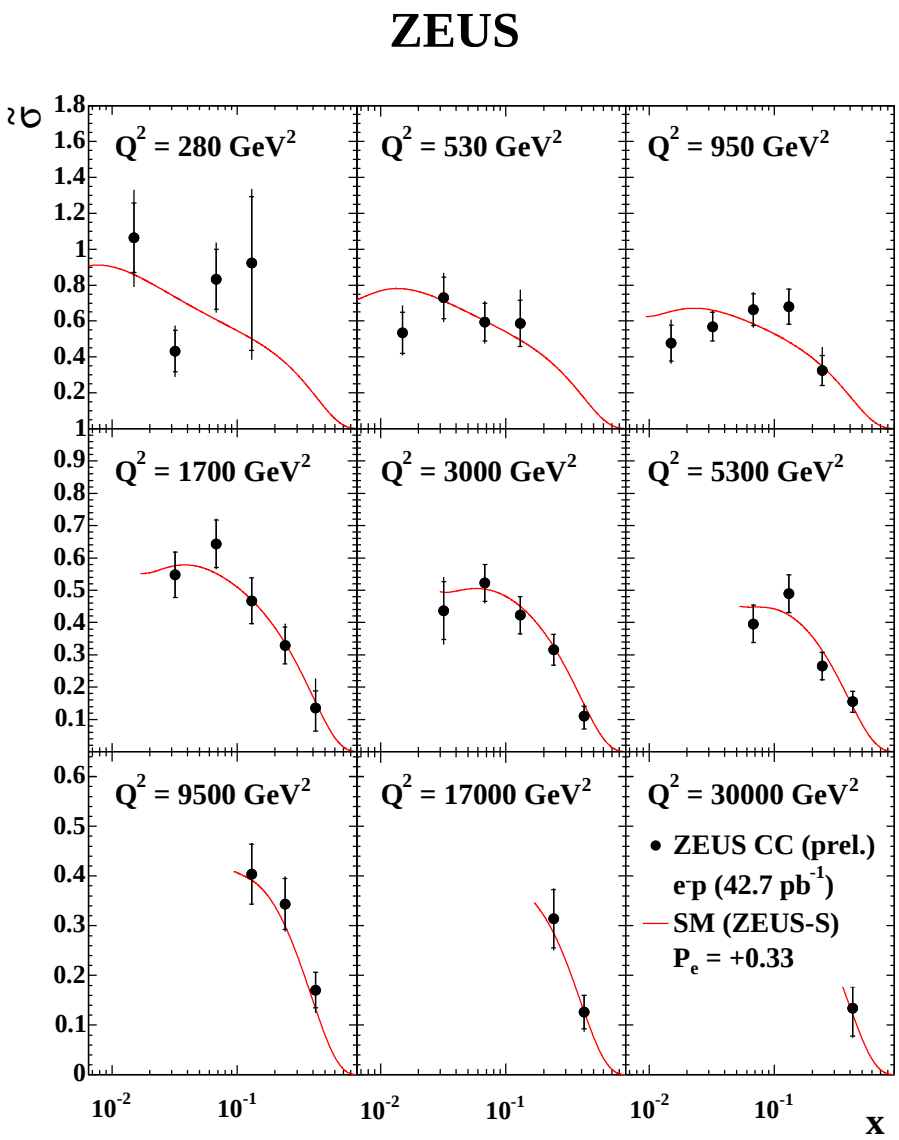


σ (P_e=-1) = 7.4 $\pm$ 3.9 (stat.) $\pm$ 1.2 (syst.)

σ (P_e=+1) = 0.8 $\pm$ 3.1 (stat.) $\pm$ 5.0 (syst.)

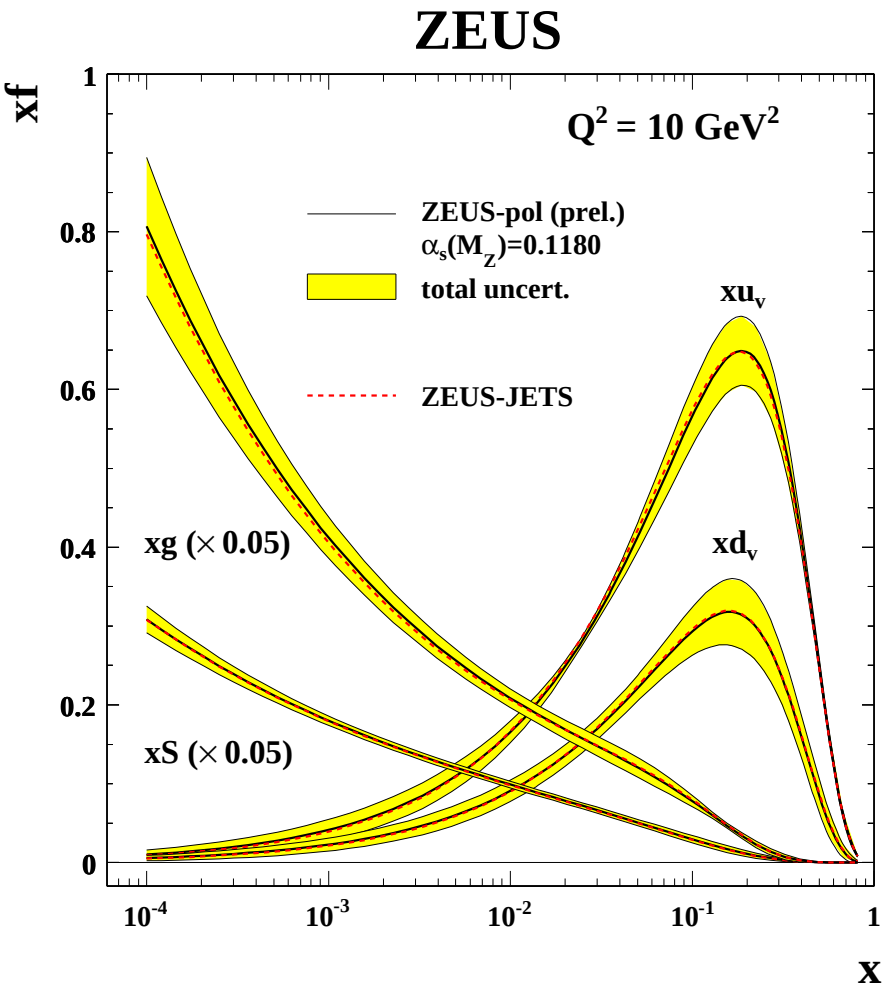
Charged current cross sections

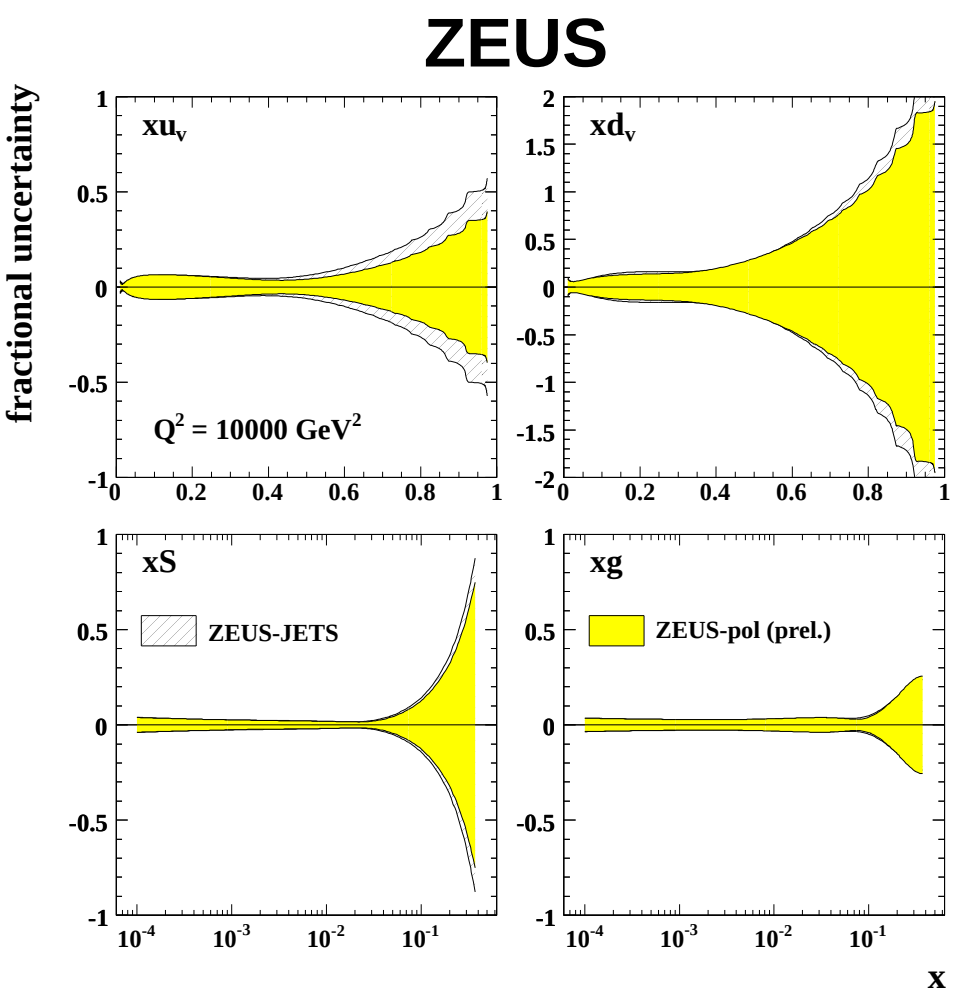




Valuable information for de-convoluting quark flavours and future QCD fits.

Combined EW and QCD fits

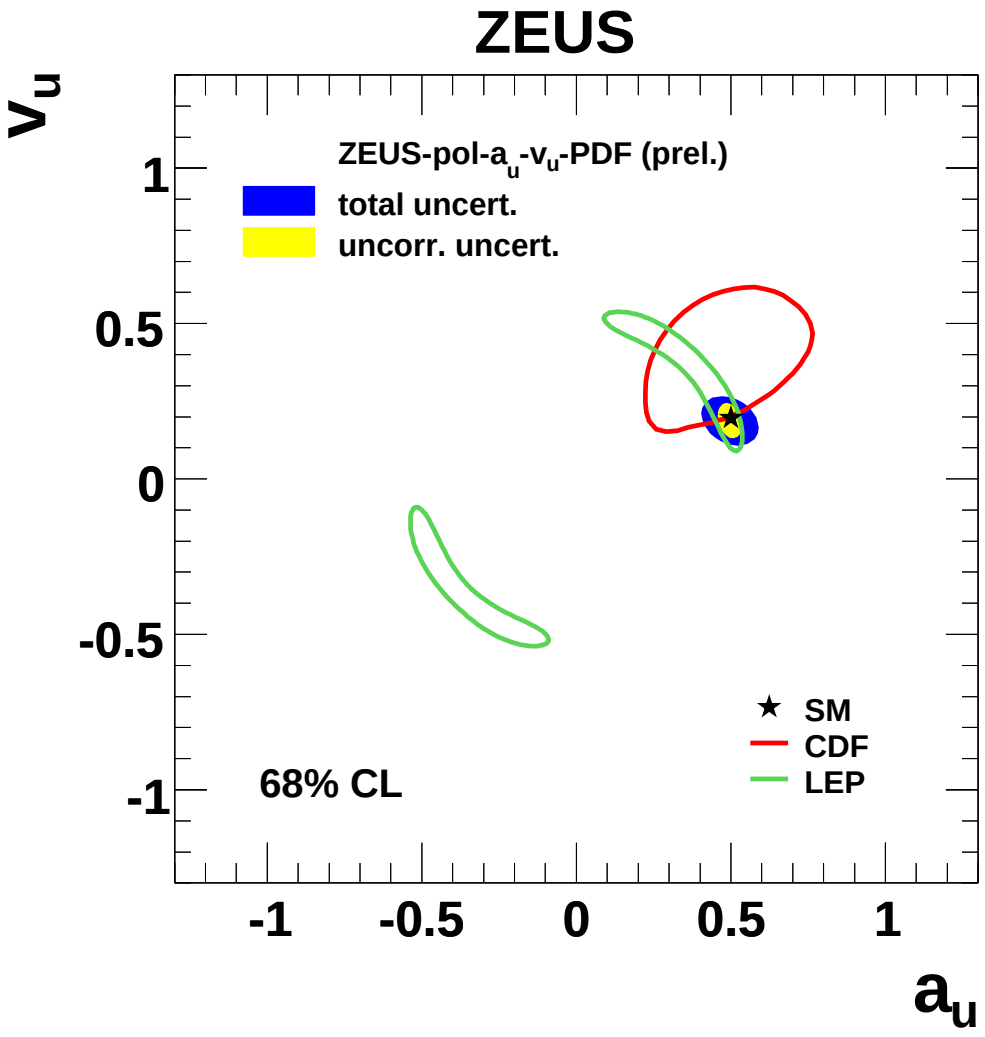


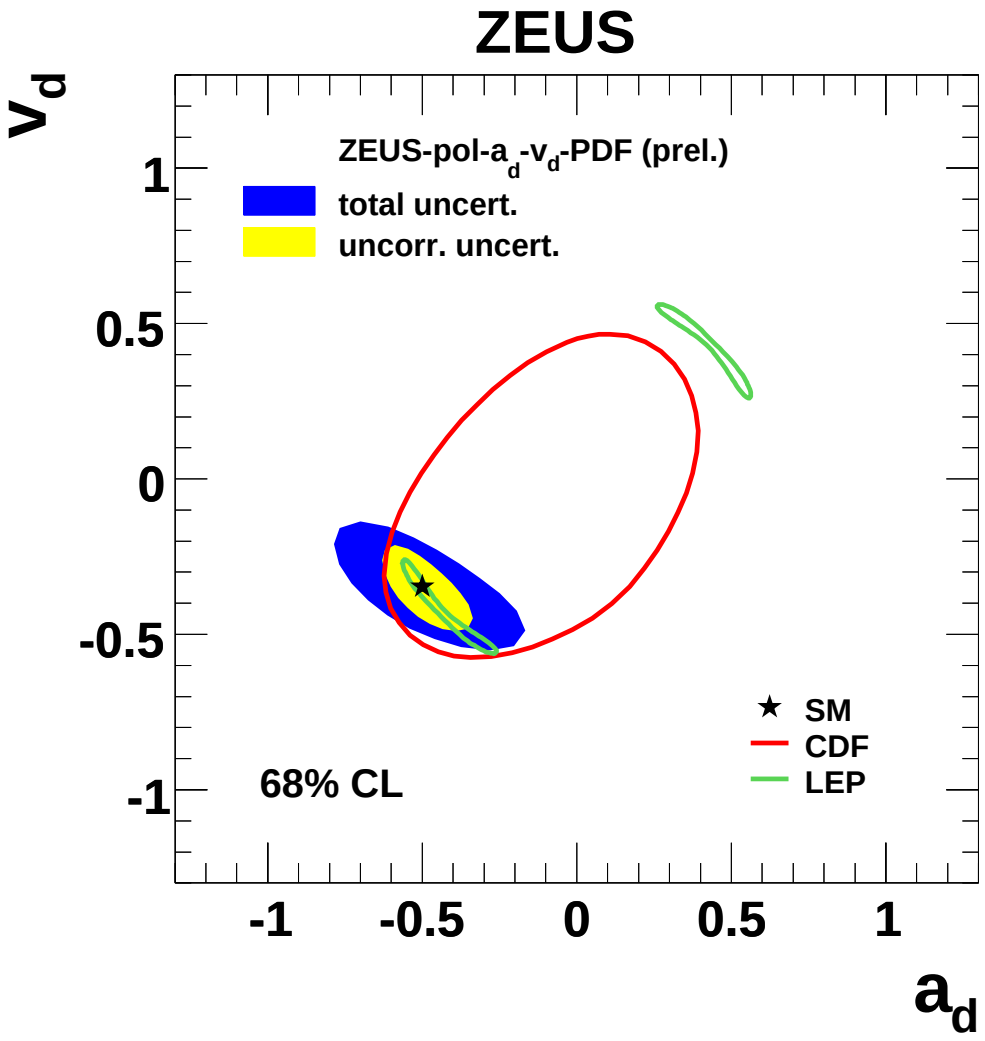


Consistency check of new data and fit

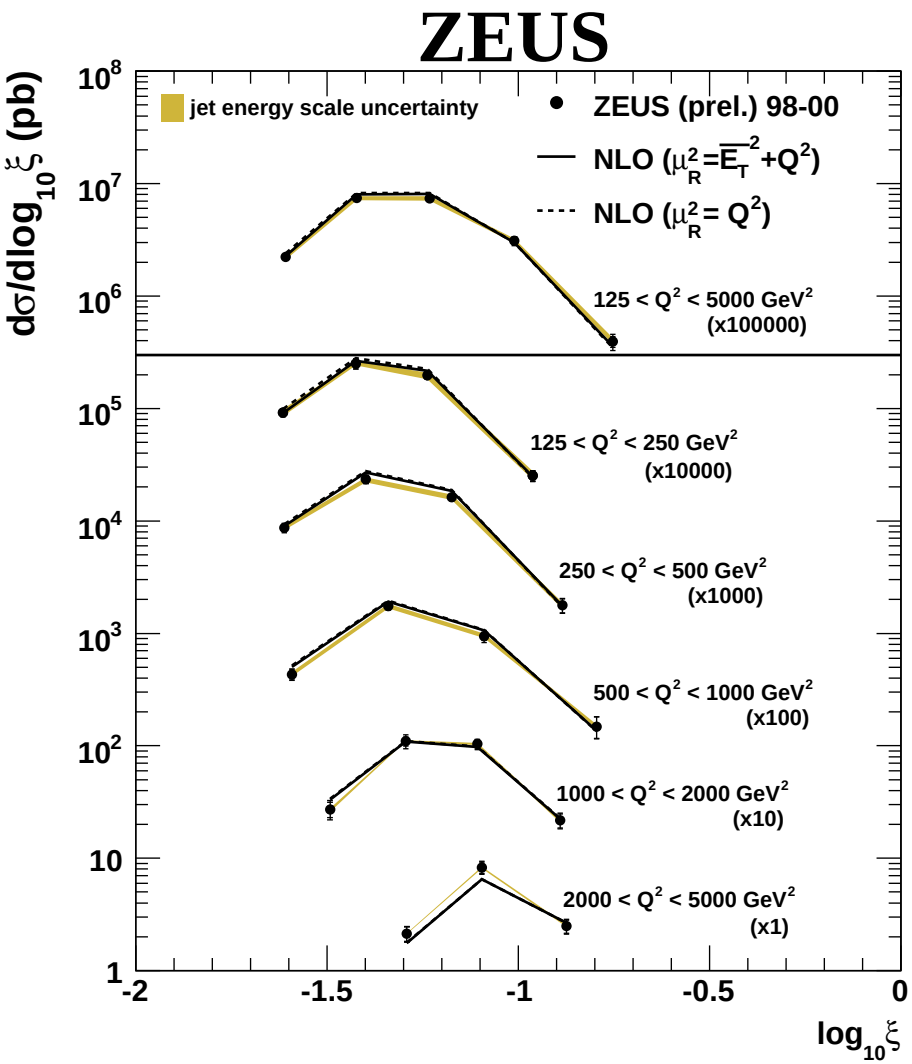
Improvement in error for u_v

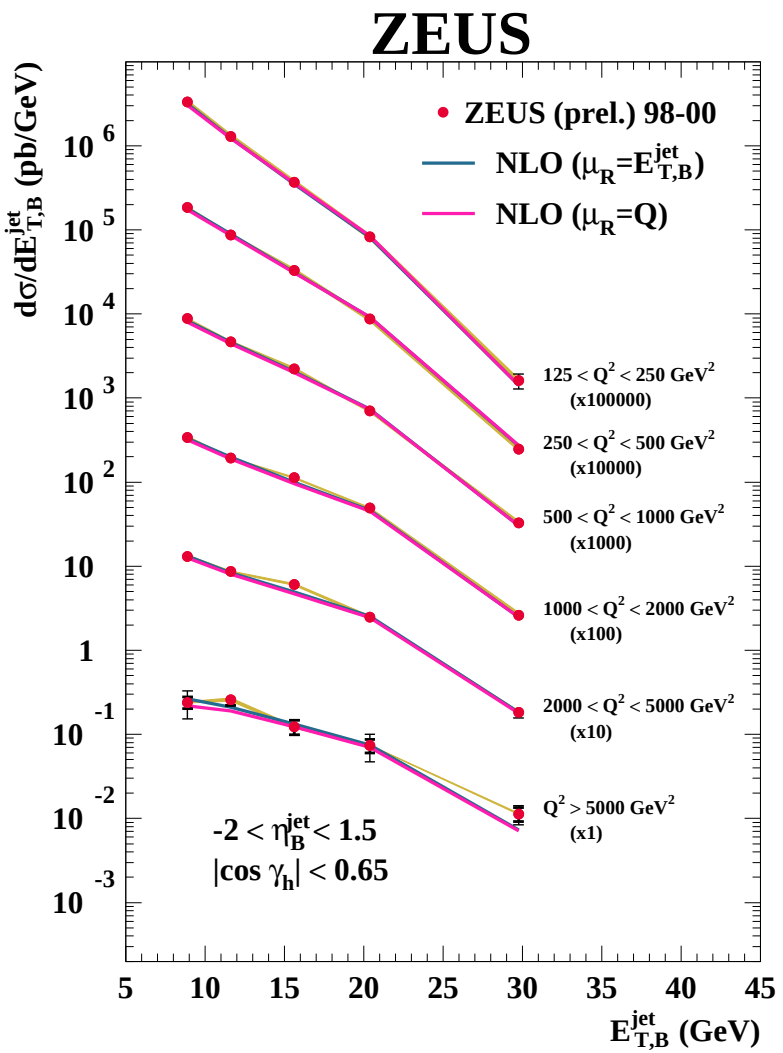
Combined EW and QCD fits





Jet measurements: input to QCD fits



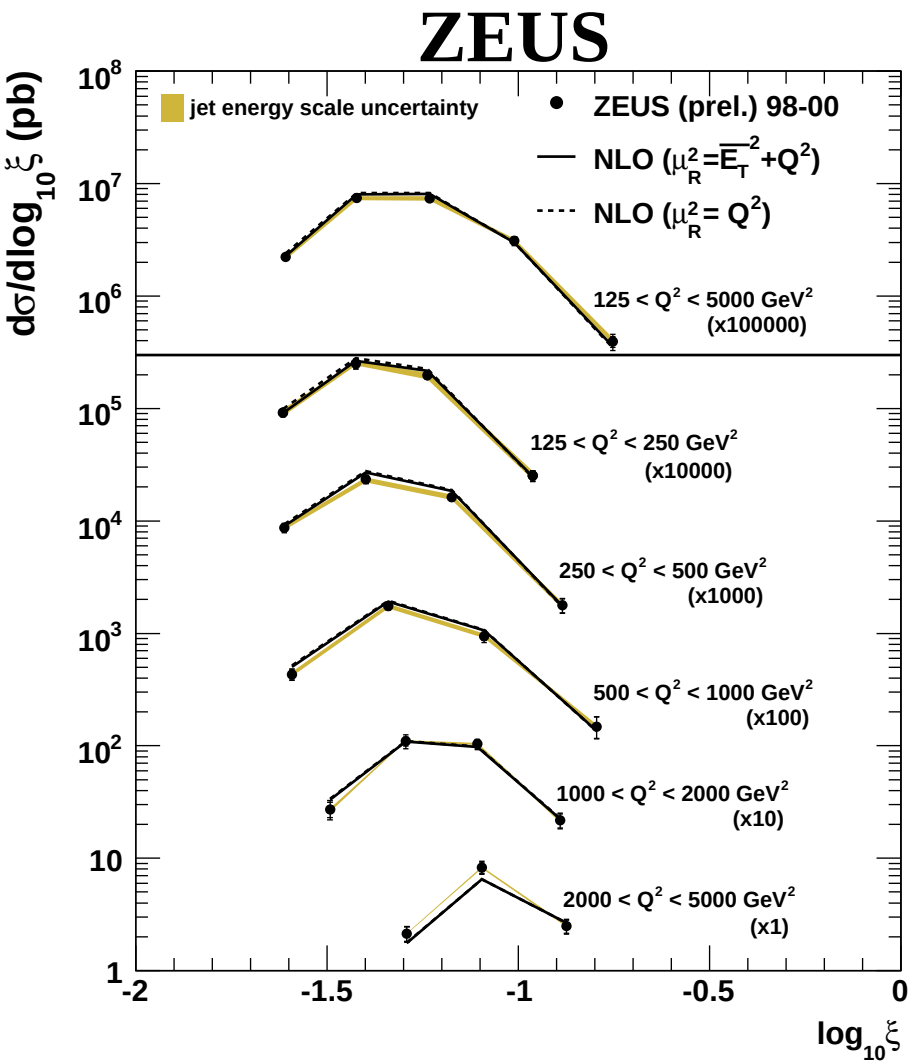


$$\xi = x_{\mathrm{Bj}}(1 + M_{\mathrm{jj}}^2/Q^2)$$

Also high x DIS, jets in γp, heavy quarks, prompt photons

Goal: combined description of many different processes and accurate PDFs

Jet measurements: input to QCD fits



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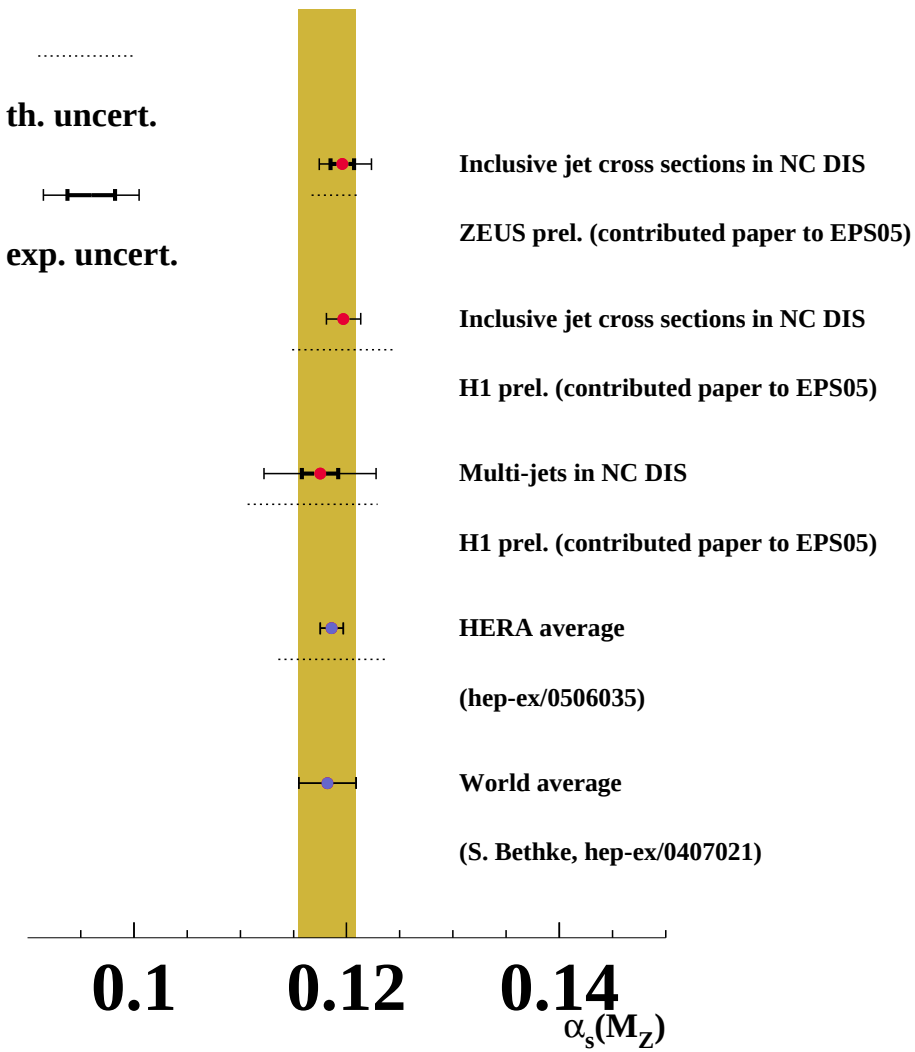


Also high x DIS, jets in γp, heavy quarks, prompt photons

Goal: combined description of many different processes and accurate PDFs

Isolated leptons at high transverse momentum

Further extended search for isolated leptons at high p_T

Looked for electrons in $e^- p$ data: 98-99 (17 pb^{-1}) and 04-05 (126 pb^{-1})

Isolated e candidates	$P_T^X > 25$ GeV
ZEUS (prel.) 98-05 $e^- p$ (143 pb^{-1})	3/2.9$\pm$0.5(53%)
ZEUS (prel.) 99-04 $e^+ p$ (106 pb^{-1})	1/1.5$\pm$0.1(78%)
ZEUS (prel.) 98-05 $e^\pm p$ (249 pb^{-1})	4/4.4$\pm$0.5(61%)
H1 (prel.) 94-05 $e^\pm p$ (279 pb^{-1})	11/4.7 $\pm$ 0.9 (69%)

ZEUS continues to see rate consistent with SM

Dijets in diffractive DIS

Applicability of QCD factorisation in diffraction?

$$\sigma_{HH'} \sim f_{H\to a} \otimes \sigma_{ab} \otimes f_{H'\to b}$$

Diffractive parton densities, f, are universal?

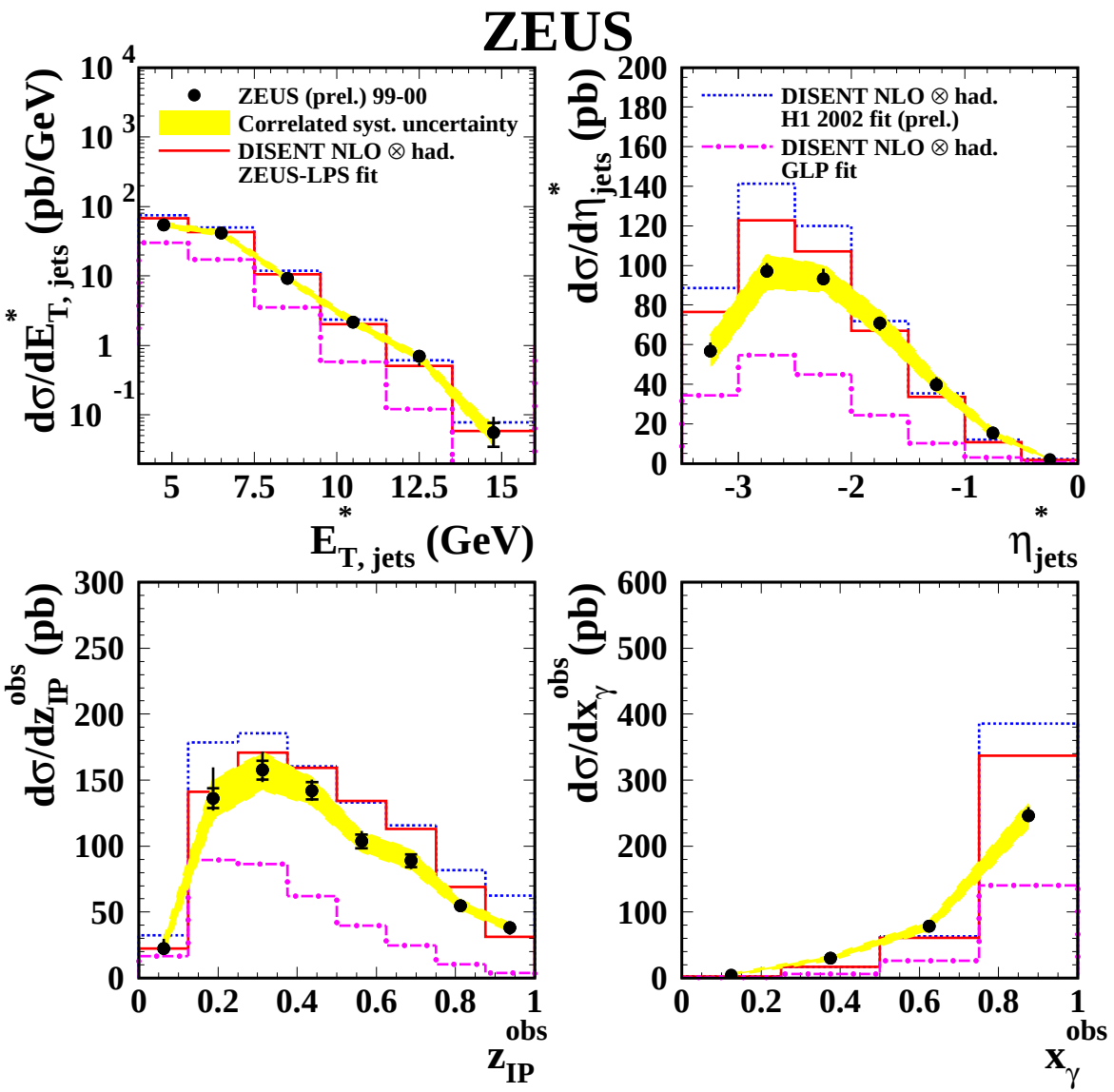
Theory overestimates data in $p\bar{p}$ and γp jet measurements

Theory predicts D^* in DIS

Now have more DPDFs available

Data are sensitive to these PDFs - they could be used

Work needed on understanding inclusive measurements

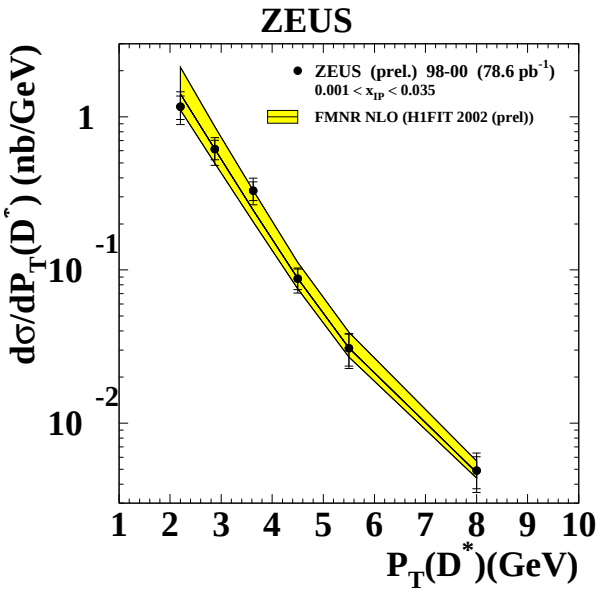


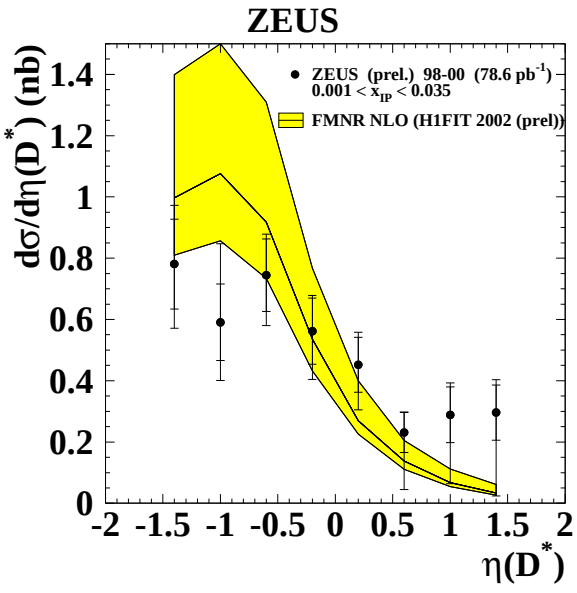
Charm in diffractive photoproduction

Theory agrees with charm photoproduction data

Recall for dijets, data/NLO $\sim$ 0.5

Importance of understanding non-diffractive measurements





Several inclusive diffractive measurements, several DPDFs and several final-state measurements $\rightarrow$ lots to be learnt.

Leading neutron production

Interaction between soft and hard physics

Particle exchange models

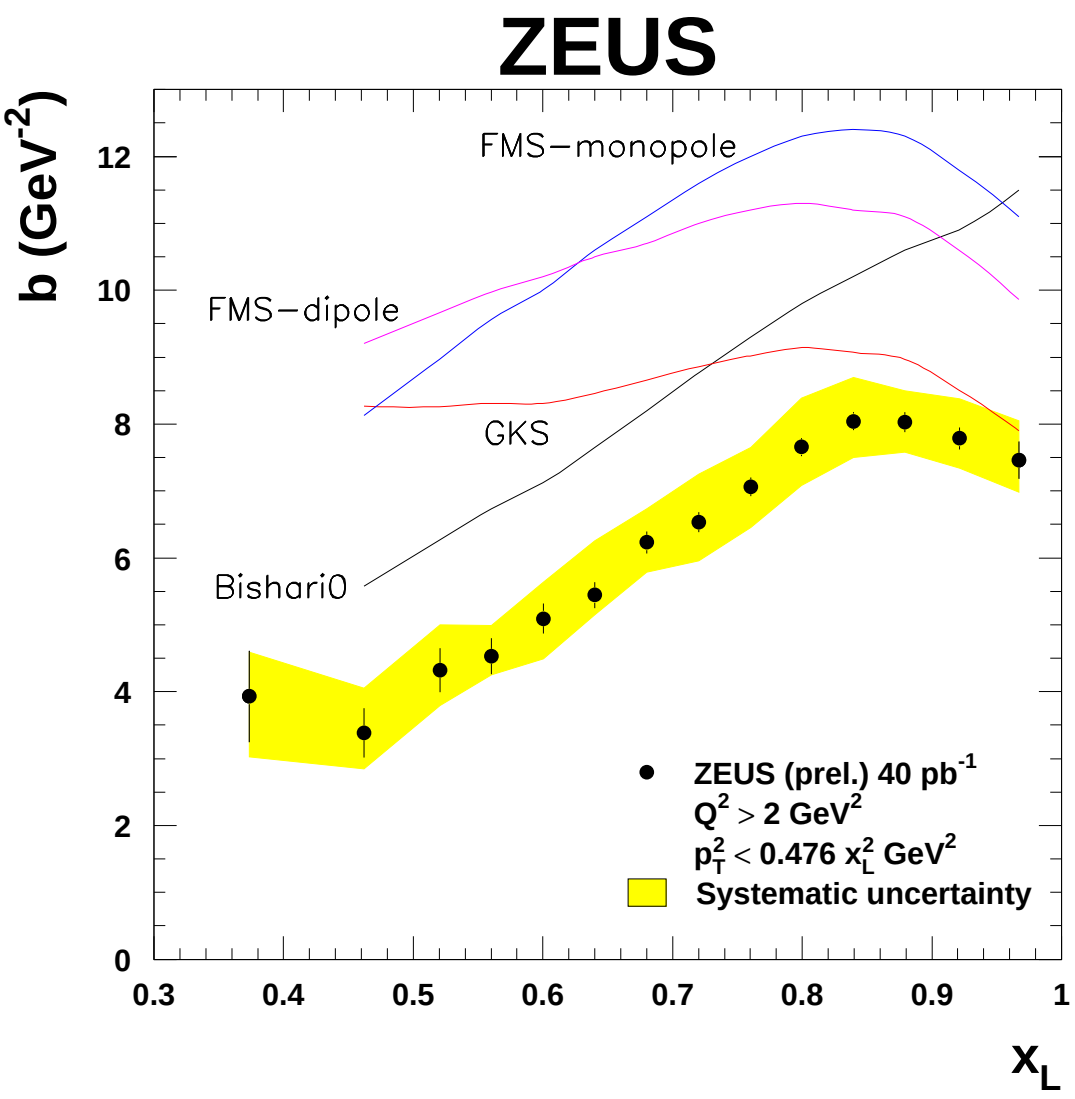
Factorisation: structure function of exchanged particle, independence of photon vertex

Fit $d\sigma/dp_T^2 \sim \exp(-bp_T^2)$

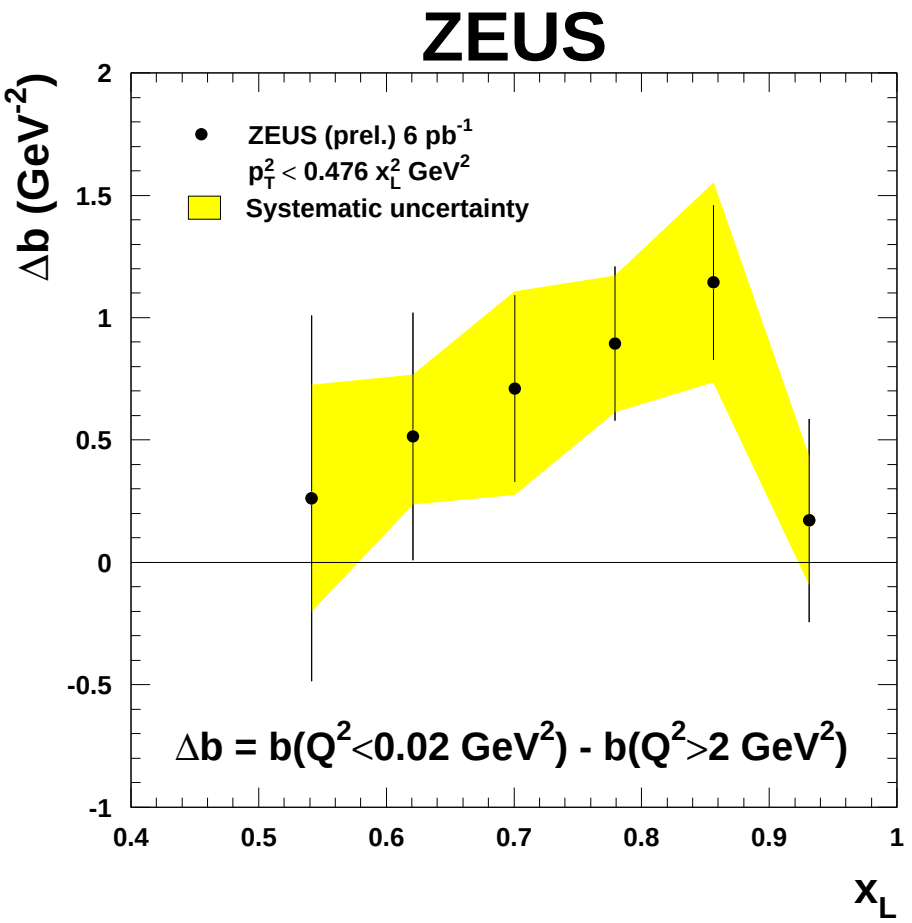
One-pion exchange model:

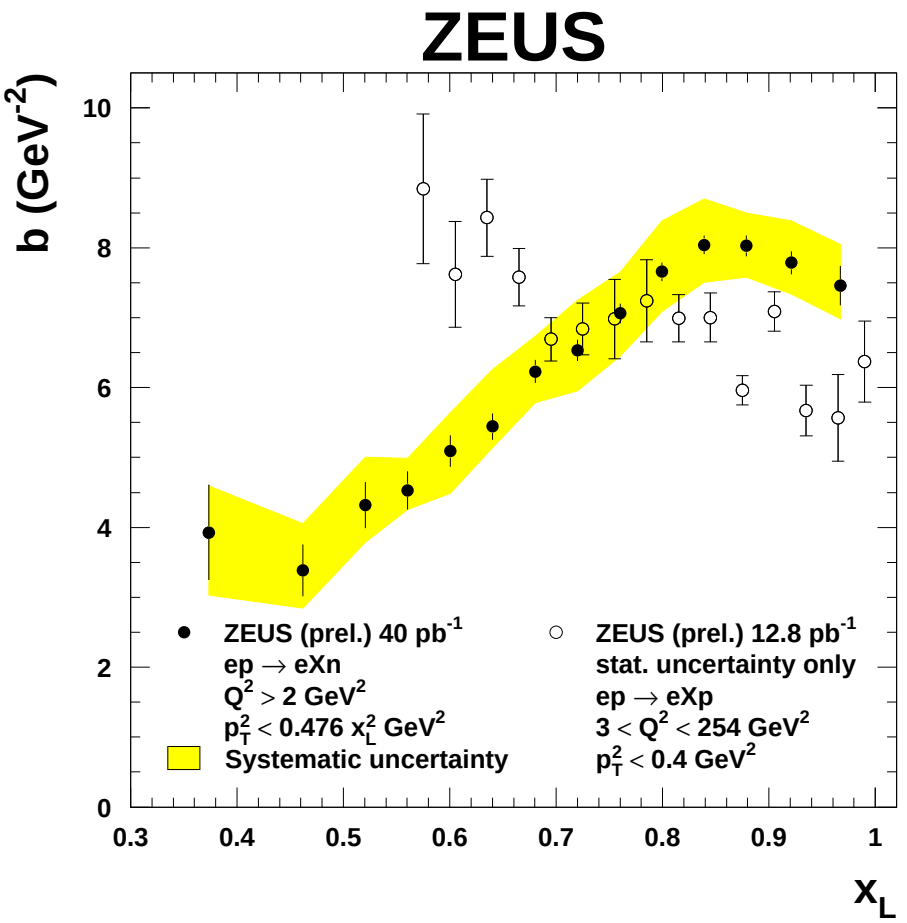
$$\frac{d^2\sigma_{ep\to e'nX}}{dx_L dt} = f_{\pi/p}(x_L, t)\sigma^{e\pi}(s')$$

Data not well described



Leading neutron production





Photoproduction b slopes clearly larger

Two samples very different

Depletion of neutrons at large p_T^2 consistent with absorption models

π exchange dominant around $0.6 < x_L < 0.8$

Protons and anti-deuterons

Production of light nuclei?

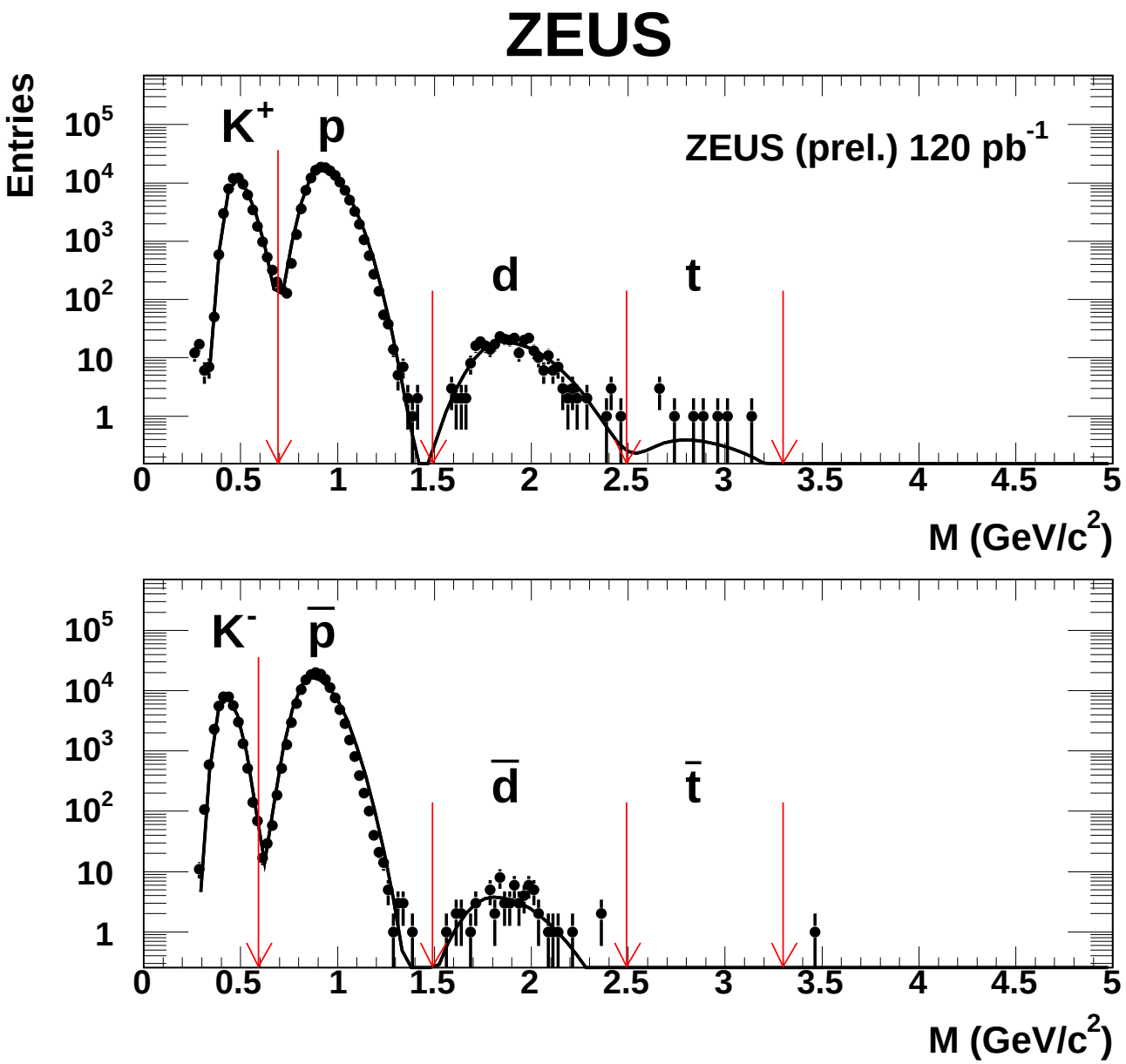
Relation between anti-deuterons and pentaquarks?

Results in e^+e^- and γp

Now look in DIS

Analysis uses:

- **primary interaction**
- **energy loss**



Protons and anti-deuterons

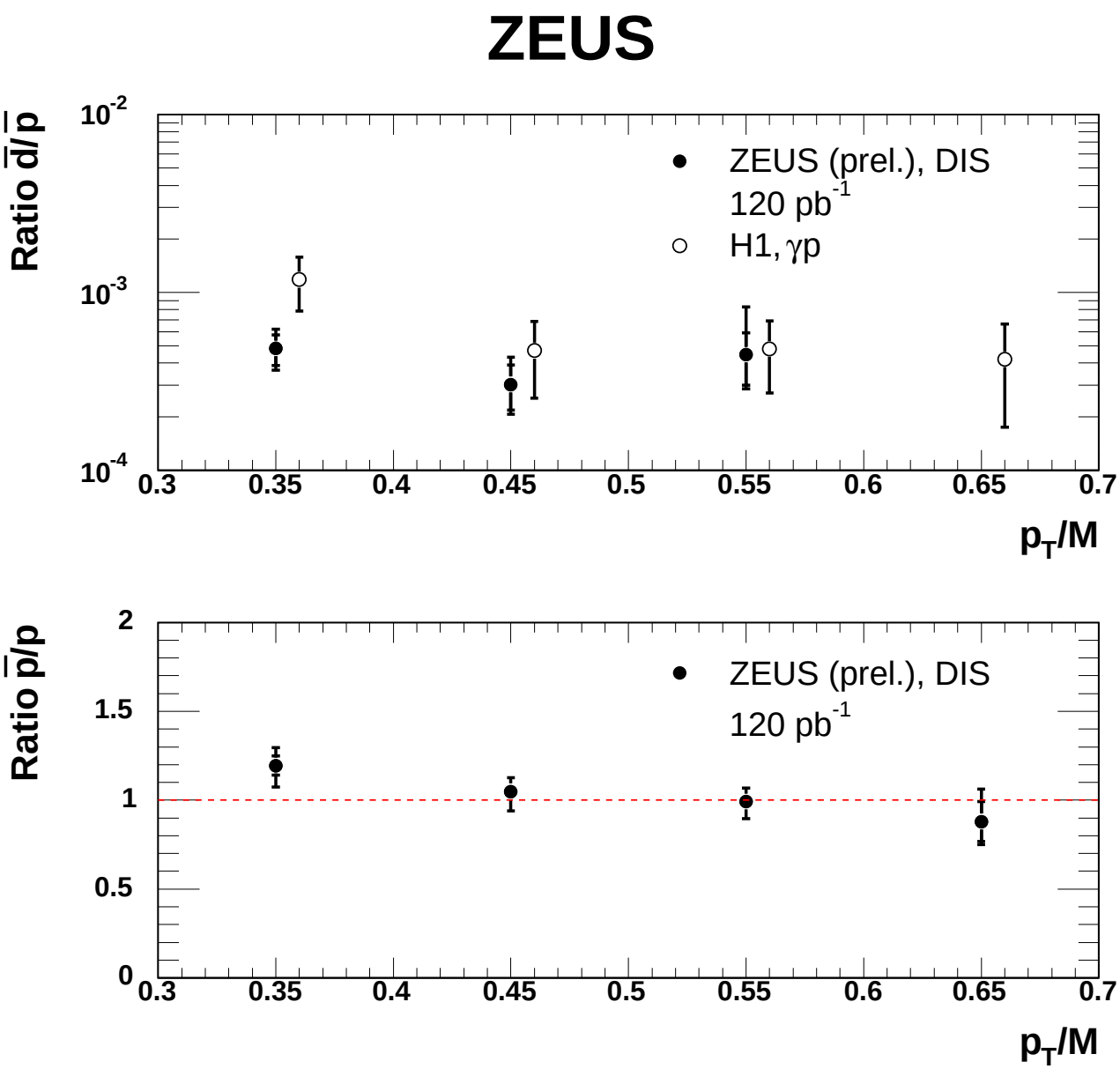
Agreement for $\bar{d}/\bar{p}$ with H1 γp measurements

p and $\bar{p}$ produced with same rate

Interesting first measurement

Compatibility with coalescence model?

More to learn from measuring deuterons...



Three and four jets in photoproduction

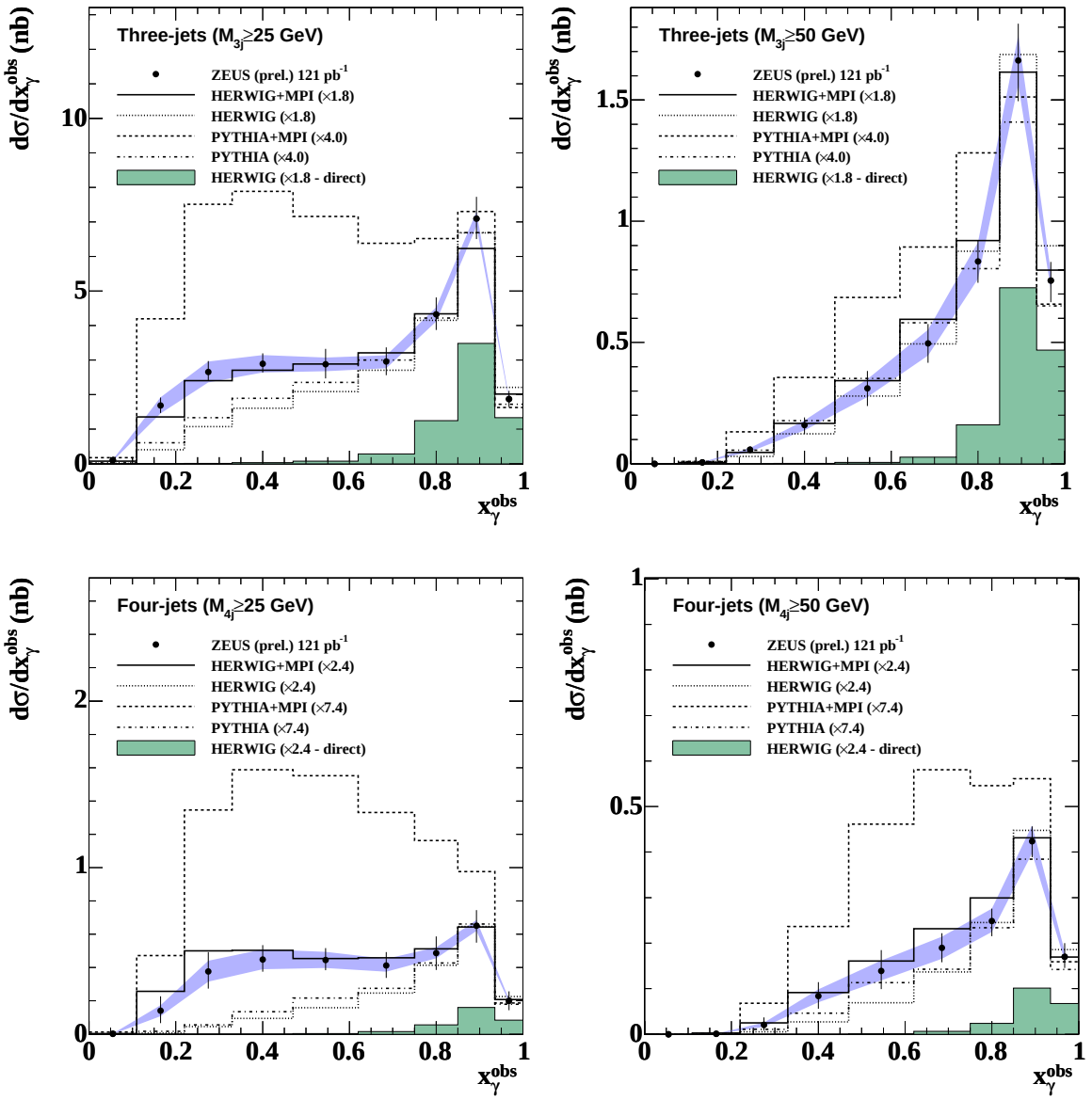
Only measurements of 4 jets in photoproduction

$$x_\gamma^{\text{obs}} = \frac{\sum_{i=1}^{n} E_{T,i}^{\text{jet}} \exp(-\eta_i^{\text{jet}})}{2yE_e}$$

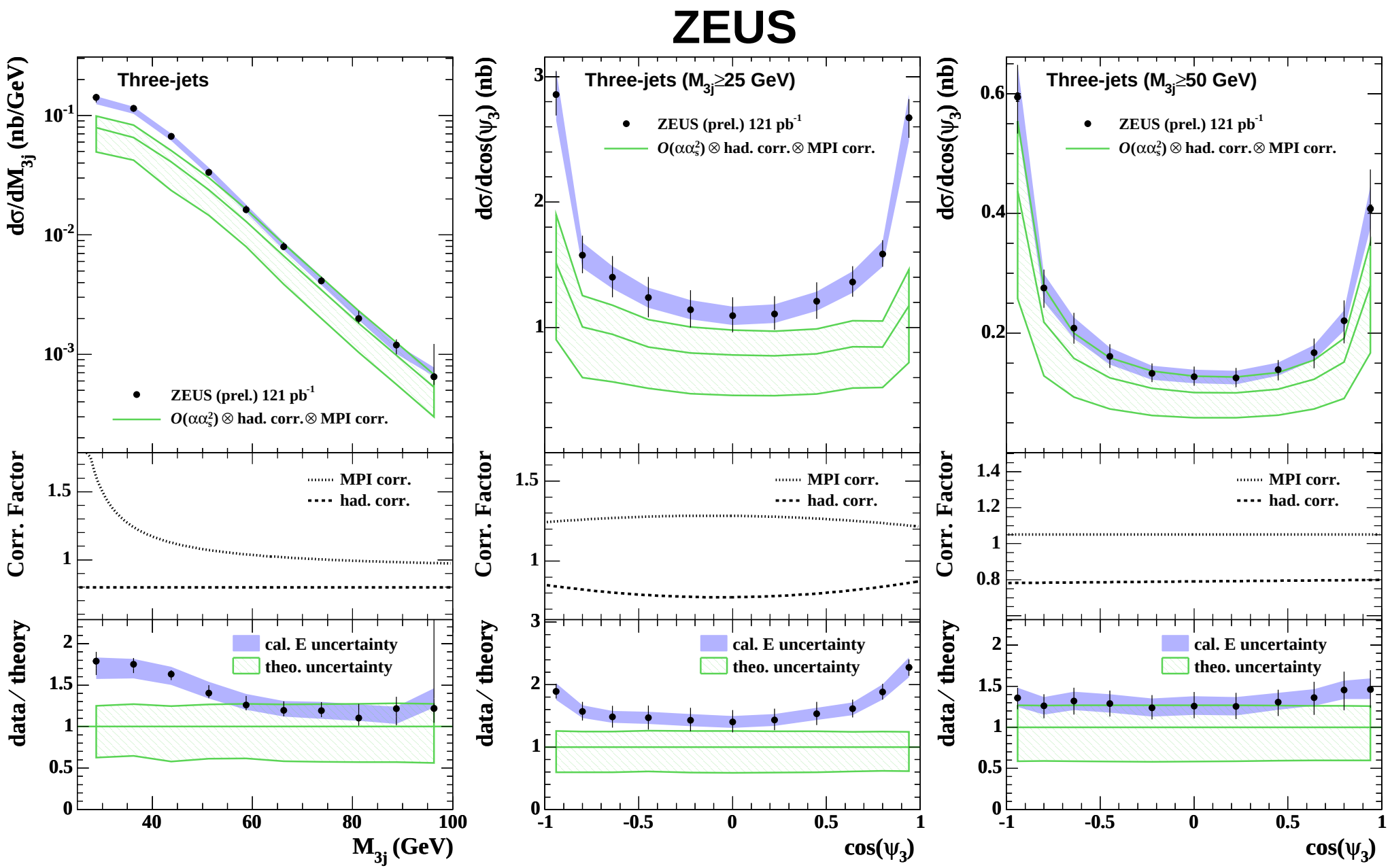
Can adjust multi-parton interaction model to agree with data

Useful data for tuning and testing Monte Carlos and higher-order predictions

ZEUS



Three and four jets in photoproduction



Desperately need NLO for 3 jets and LO for 4 jets - excellent data to compare to.

Charm jet production

Wide range of variables to validate QCD calculations

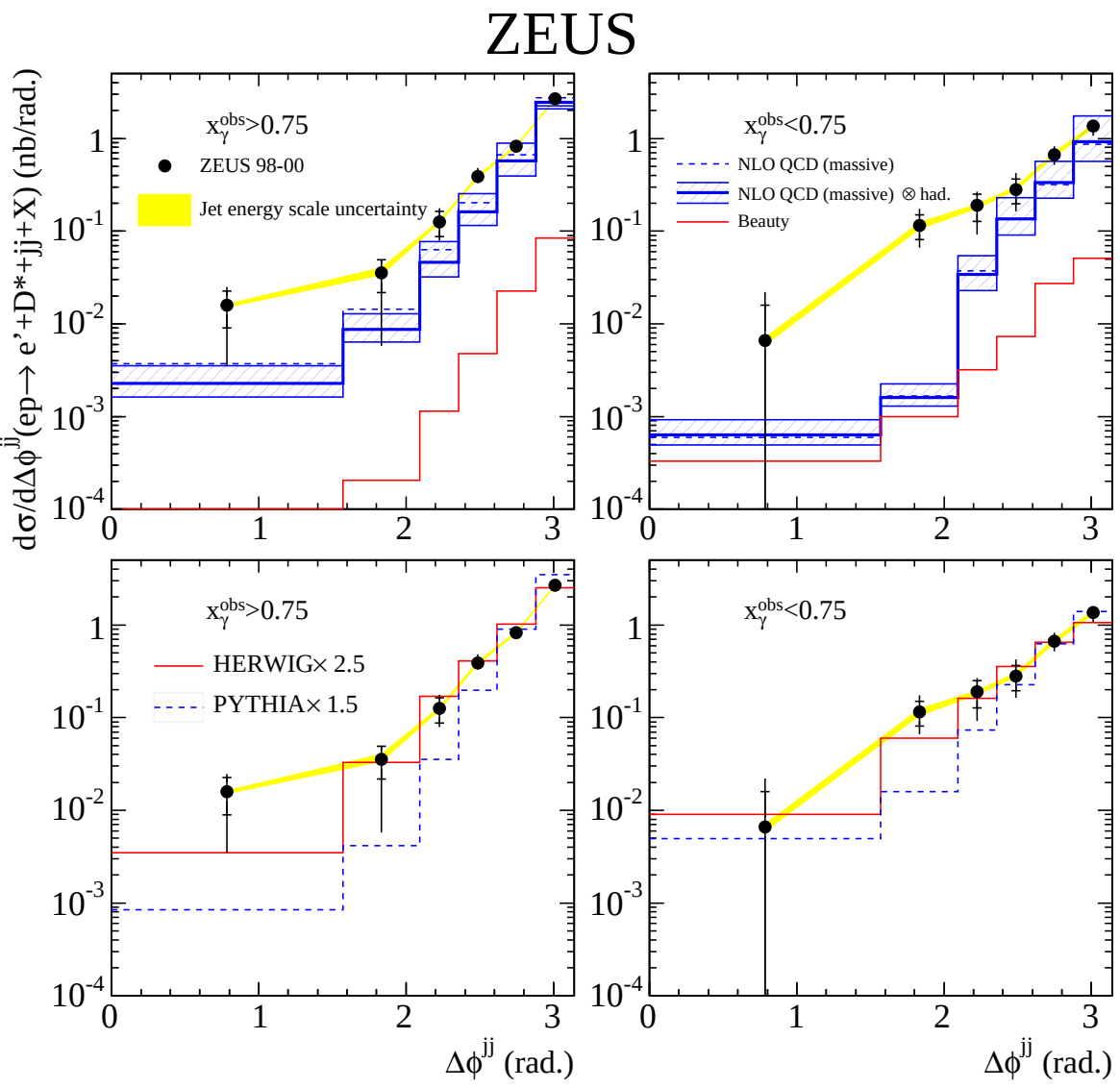
General agreement for inclusive jets with charm

Highlighted some areas of discrepancy for dijets

- **low x_γ^{obs}**
- **where higher-order topologies are prevalent**

HERWIG: excellent description

Benefit from improved higher-order (or simulation thereof) calculations



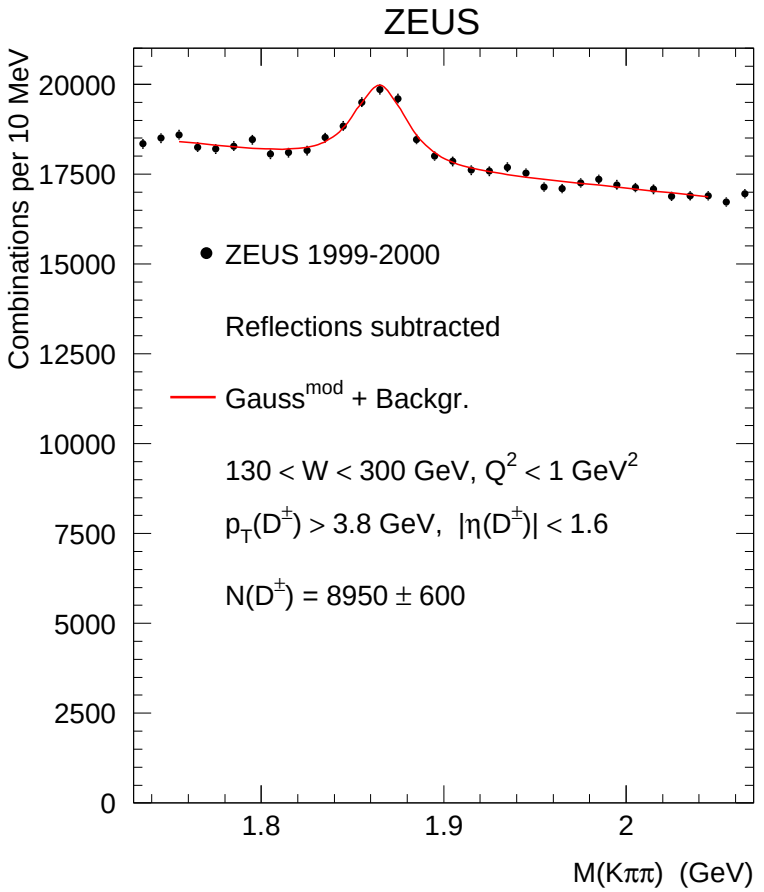
Charm fragmentation

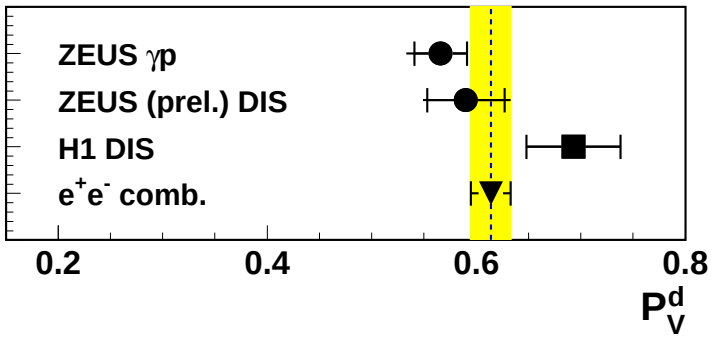
Clean, high-statistics signals

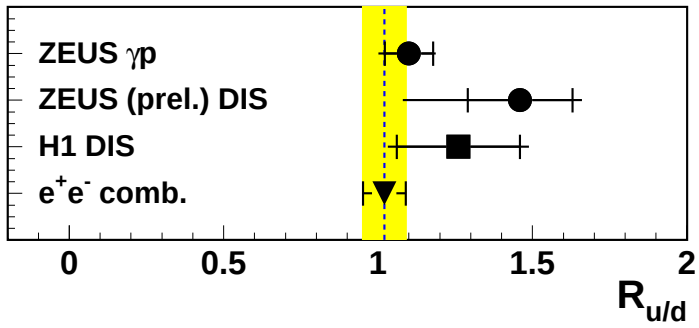
Also measured branching fractions

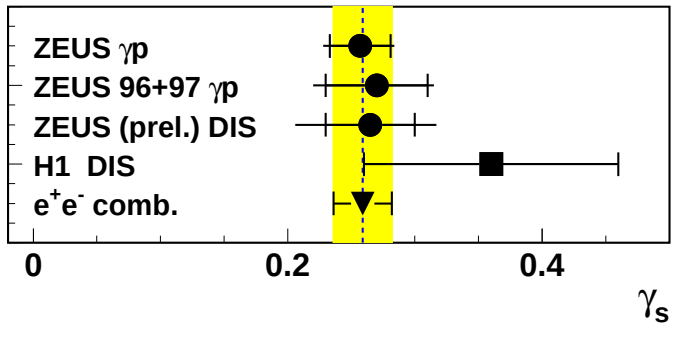
Competitive with combined e^+e^- numbers

Indicates charm fragmentation is universal



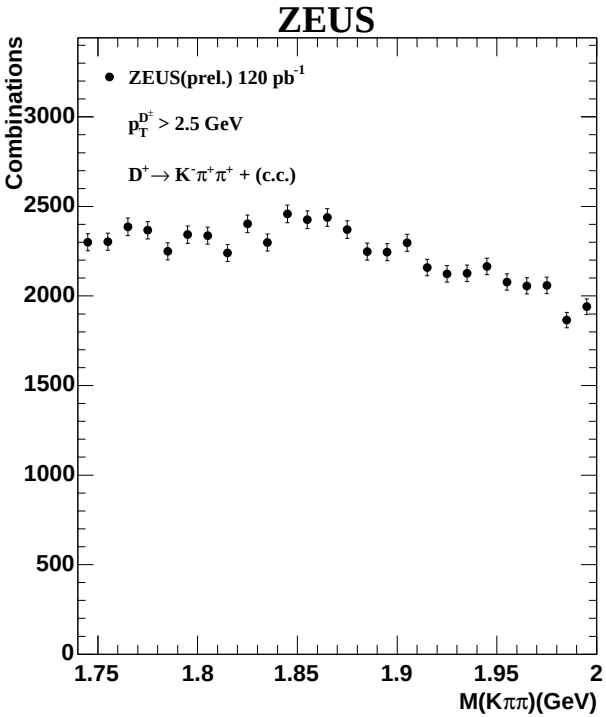


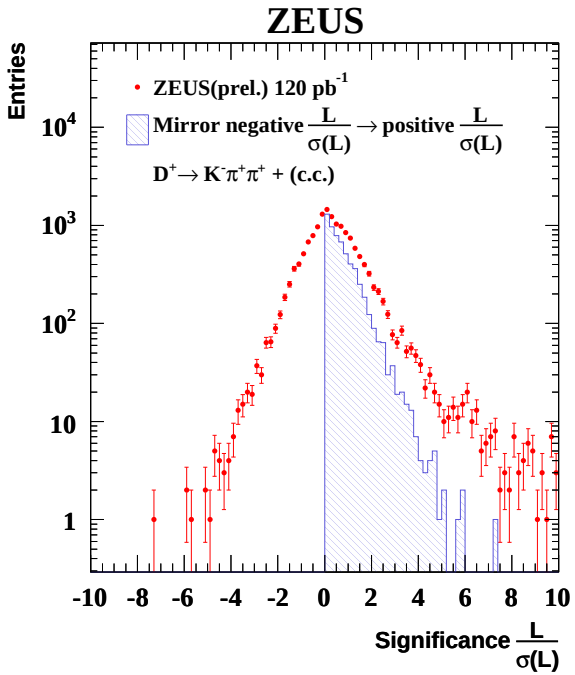


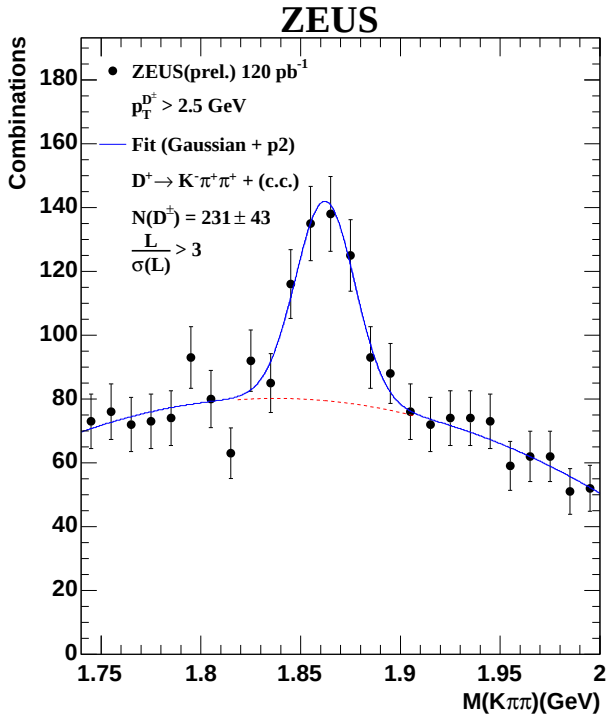


Heavy quarks at HERA II: outlook

Have now produced much improved vertex detector alignment using ep data







Starting to resolve clean signals from the large background

Look forward to accurate measurements of $F_2^{c\bar{c}}$ and $F_2^{b\bar{b}}$ in the near future.

Conclusion

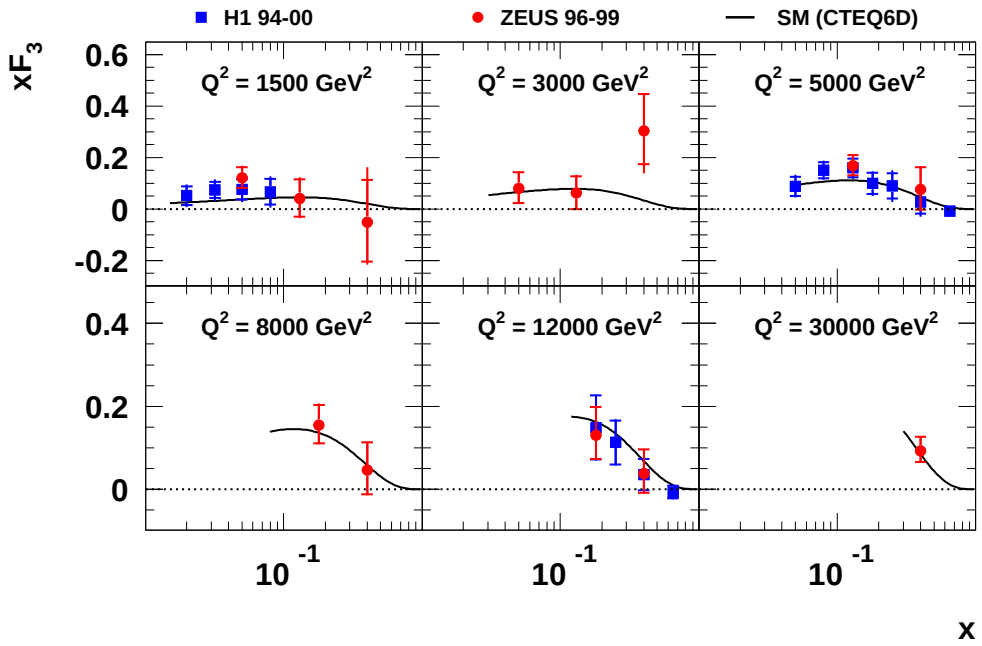
Impressive new results in inclusive DIS at HERA II are having a real impact on combined EW and QCD fits

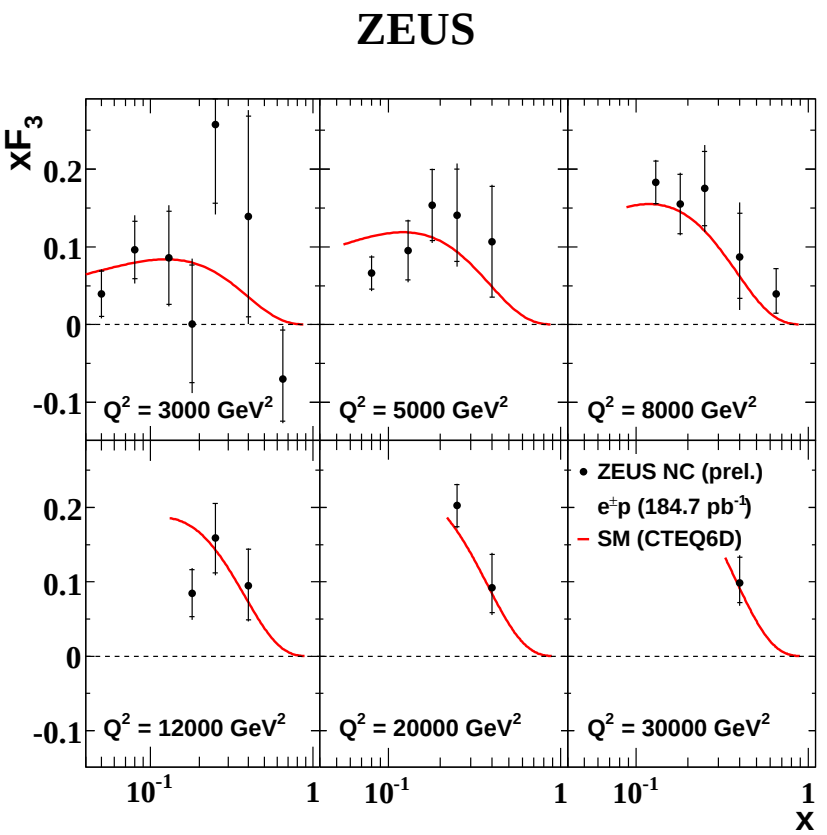
Diffractive final-state data can have an impact on QCD fits to diffractive PDFs

Still producing first measurements: anti-deuterons in DIS and 4 jets in γp

Data on heavy quarks still challenging theory and adding accurate measurements - look forward to increased precision on the structure functions

Back-ups


H1 94-00
ZEUS 96-99
SM (CTEQ6D)
xF_3
Q^2 = 1500 GeV^2
Q^2 = 3000 GeV^2
Q^2 = 5000 GeV^2
Q^2 = 8000 GeV^2
Q^2 = 12000 GeV^2
Q^2 = 30000 GeV^2
0.6
0.4
0.2
0
-0.2
10^{-1}
x


ZEUS
xF_3
Q^2 = 3000 GeV^2
Q^2 = 5000 GeV^2
Q^2 = 8000 GeV^2
Q^2 = 12000 GeV^2
Q^2 = 20000 GeV^2
Q^2 = 30000 GeV^2
ZEUS NC (prel.)
$e^{\pm}p$ (184.7 pb^{-1})
SM (CTEQ6D)
0.2
0.1
0
-0.1
10^{-1}
1
x