ZEUS Results

E. Tassi - Calabria Univ. and INFN

DIS 2009 Workshop - Madrid

Outline

- Inclusive Measurements and Proton Structure
  - HERA-I H1-ZEUS combined cross sections and HERAPDF0.2
  - HERA-II Low Q^2 NC e^+p Cross sections, F_2 and F_L
  - HERA-II High-Q^2 NC/CC e^-p and CC e^+p cross sections
  - ZEUS 2009 Proton's PDFs
  - Inclusive diffraction and dPDFs
- Exclusive processes and pQCD
  - Jet production in NC DIS and α_s
  - Subjets in NC DIS
  - Semileptonic Charm and Beauty in DIS
  - Beauty in γp
  - Prompt-photon production

ZEUS Results for DIS09

Electroweak:

- Single Top production — Stefano Antonelli
- Isolated Leptons — Gerhard Brandt
- Multi-leptons — Monica Turcato

Inclusive:

- FL — Julia Grebeniuk
- High-Q2 NC/CC — Amanda Cooper-Sarkar
- H1/ZEUS Combination — Enrico Tassi
- HERAPDF0.2 — Voica Radescu

Hadronic Final States:

- Jet Substructure — Elias Ron
- K0sK0s — David Saxon
- Scaled momentum distributions — John Morris
- Angular Correlations in 3-jets — Steve Magill
- Jet Cross Sections in DIS and gp — Claire Gwenlan
- Prompt-photon production — Matthew Forrest

Diffraction:

- Inclusive Diffraction — Marta Ruspa
- Factorization Tests — Wojtek Slominski
- Leading Barions — Graziano Bruni
- Vector Meson Production — Aharon Levy

Heavy Flavours:

- Charm production in DIS — Philipp Roloff
- Beauty Production in DIS — Silvia Miglioranzi
- J/psi helicity distributions — Alessandro Bertolin
- Charm Fragmentation — Leonid Gladilin

H1-ZEUS combined HERA I cross sections

New combination based on the <u>full HERA-I incl. data</u> L=240pb^{-1}

Added since DIS08:

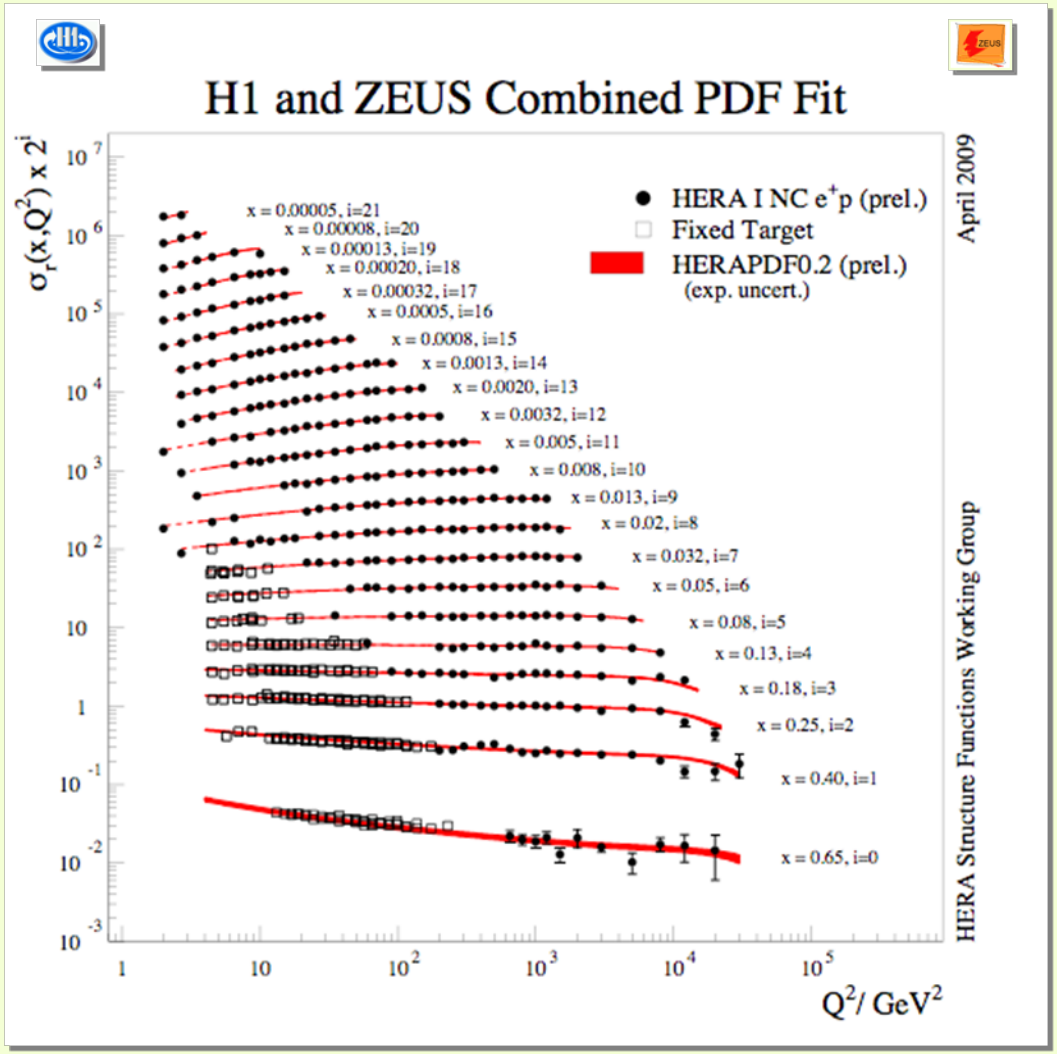
- Zeus 95-97 "low Q^2"
- H1 95-00 "low Q^2"
- H1 96-00 "Bulk"

Reduced systematic uncert. and O(1%) precision for:

$$10 < Q^2 < 100 \text{ GeV}^2$$

Used as single input to a new QCD analysis:

⇒ **HERAPDF0.2**

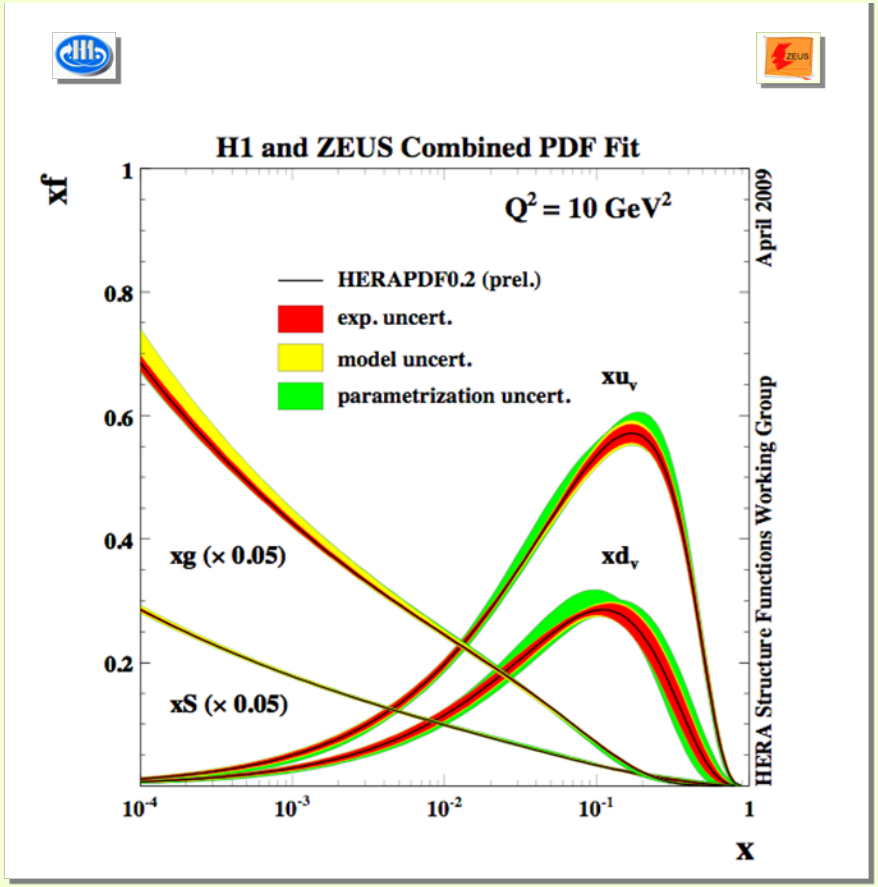


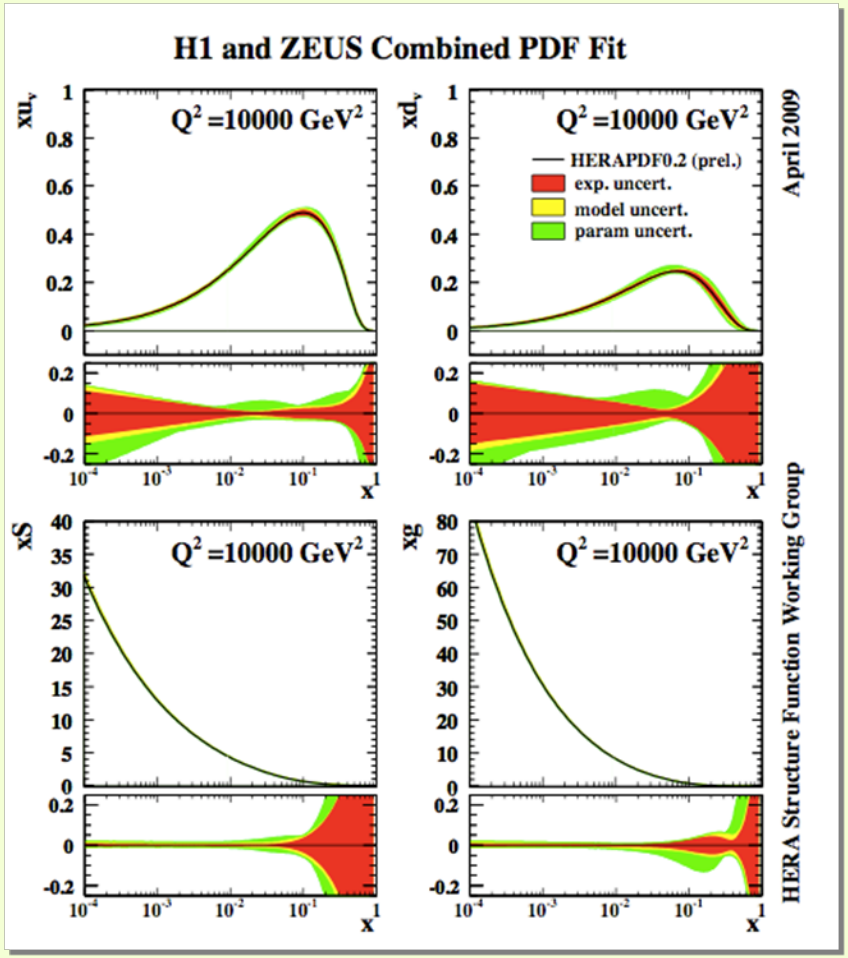
see E.T.[63]

New PDF Fit to the combined HERA-I data

HERAPDF0.2:

- Very detailed study of PDFs uncert.
- Heavy Flavours (Roberts-Thorne)





xS,xg high precision at low-x

see V. Radescu[86]

2006/07 NC e^+p at low- mid-Q^2 : "F_L runs"

Three data sets collected with dedicated triggers at the center of mass energies:

- 318 GeV (HER) 44.5pb^{-1}
- 251 GeV (MER) 7.1 pb^{-1}
- 225 GeV (LER) 13.9 pb^{-1}

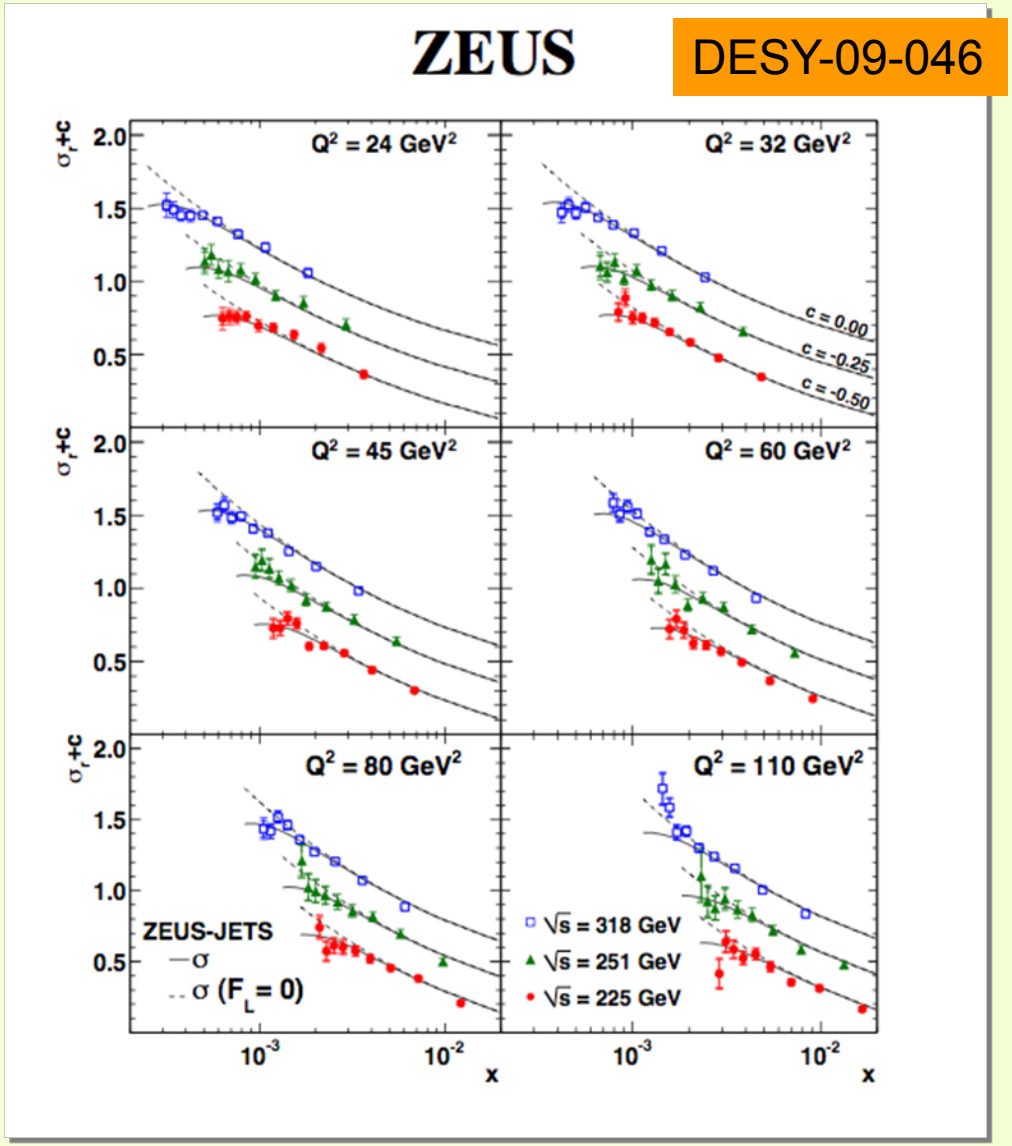
Reduced cross sections measured in the kinematic region:

$$20 < Q^2 < 130 \text{ GeV}^2$$

$$5 \times 10^{-4} < x < 0.007$$

A precise measurement and an important input to QCD analyses

see J. Grebenyuk[44]



$$\sigma_r(x, Q^2, y) = F_2(x, Q^2) - \frac{y^2}{Y_+} \cdot F_L(x, Q^2)$$

F_2 and F_L

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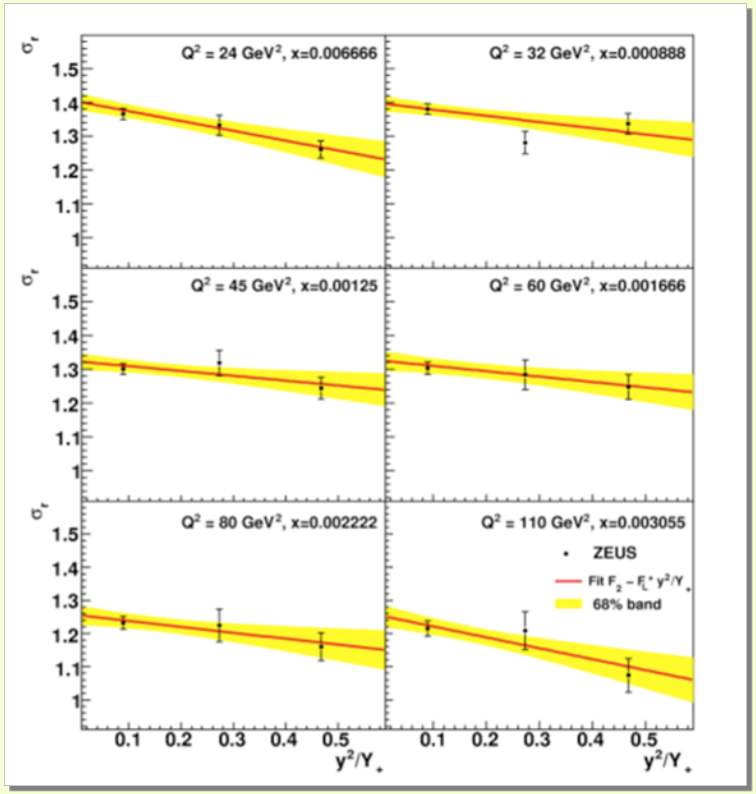
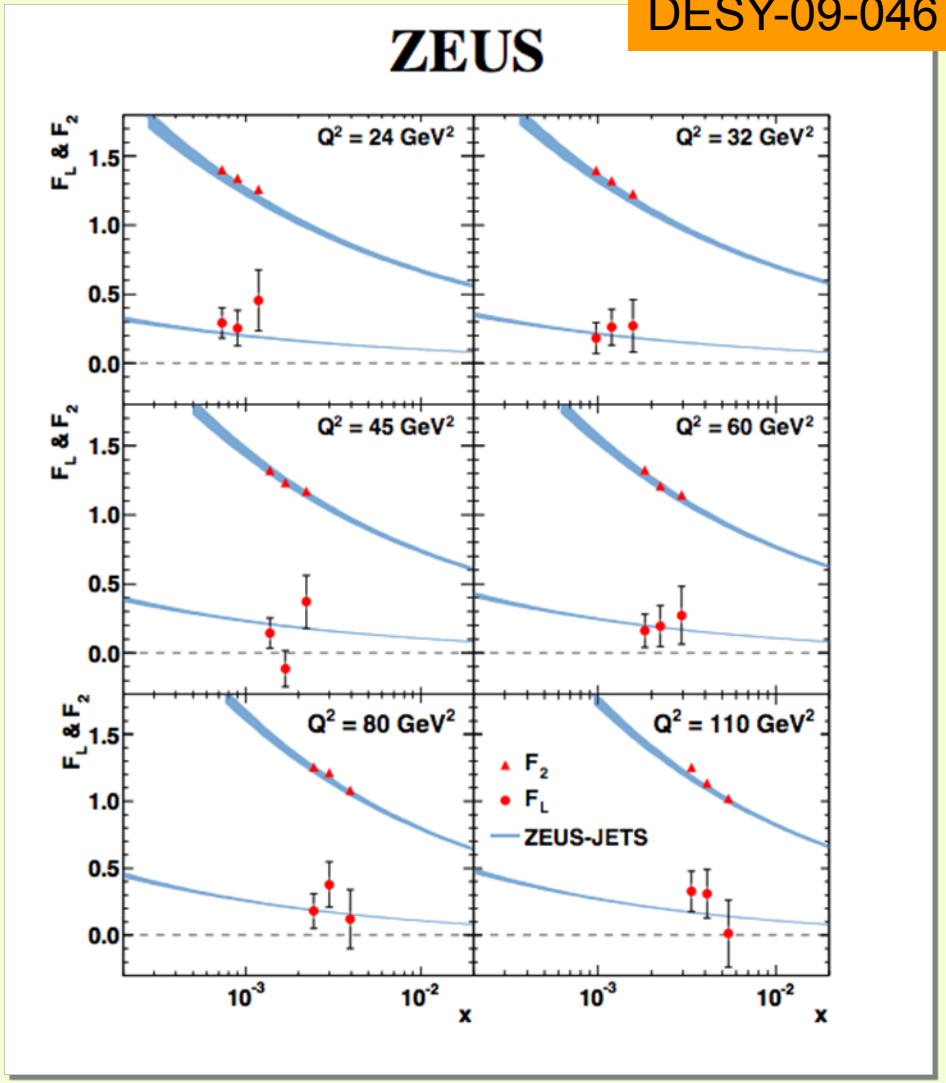
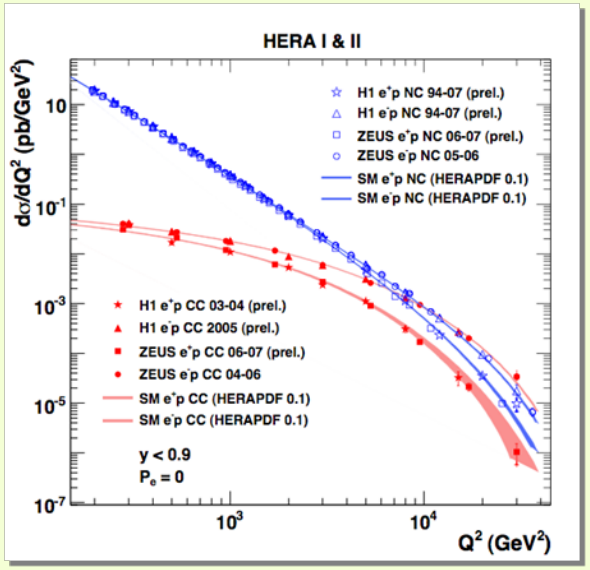




- Most precise F_2 from ZEUS in □□□ this kinematic region
- Data support non-zero F_L

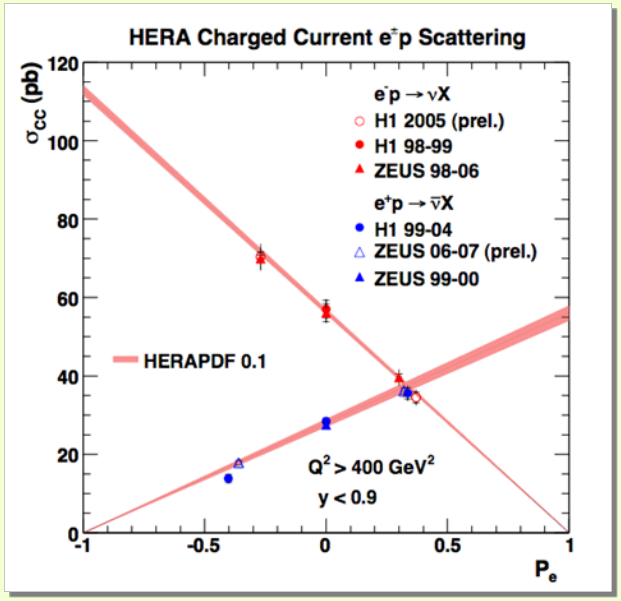
NC/CC High-Q^2 Cross sections at HERA

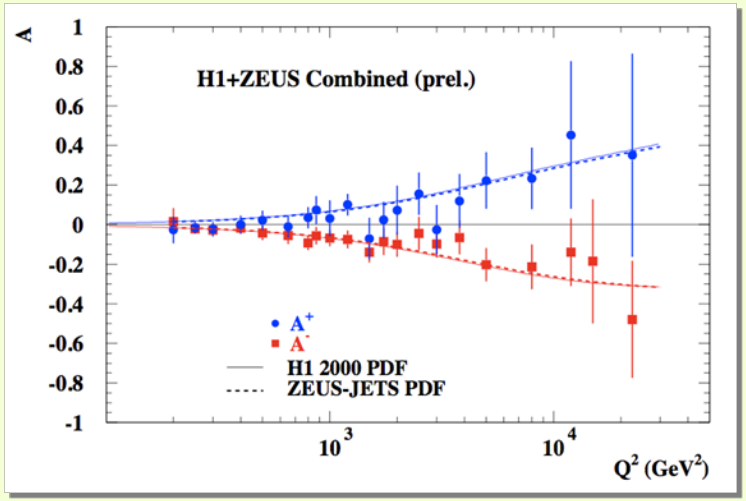


Important **Electroweak Physics** program:

- Electroweak unification
- Chiral nature of the SM
- Determination of light-quarks couplings
- Parity violation in DIS at high-Q^2 (10^{-18}m)

Here will concentrate on their impact on the proton structure





High Q^2 NC e^-p cross sections

$$\tilde{\sigma}^{e^\pm p} = \frac{xQ^4}{2\pi\alpha^2}\frac{1}{Y_+}\frac{d^2\sigma(e^\pm p)}{dx dQ^2} = \tilde{F}_2(x,Q^2) \mp \frac{Y_-}{Y_+} x\tilde{F}_3(x,Q^2)$$

$$x\tilde{F}_3 = \frac{Y_+}{2Y_-}(\tilde{\sigma}^{e^-p} - \tilde{\sigma}^{e^+p})$$

L=170 pb^{-1} (HERA-I 16 pb^{-1})

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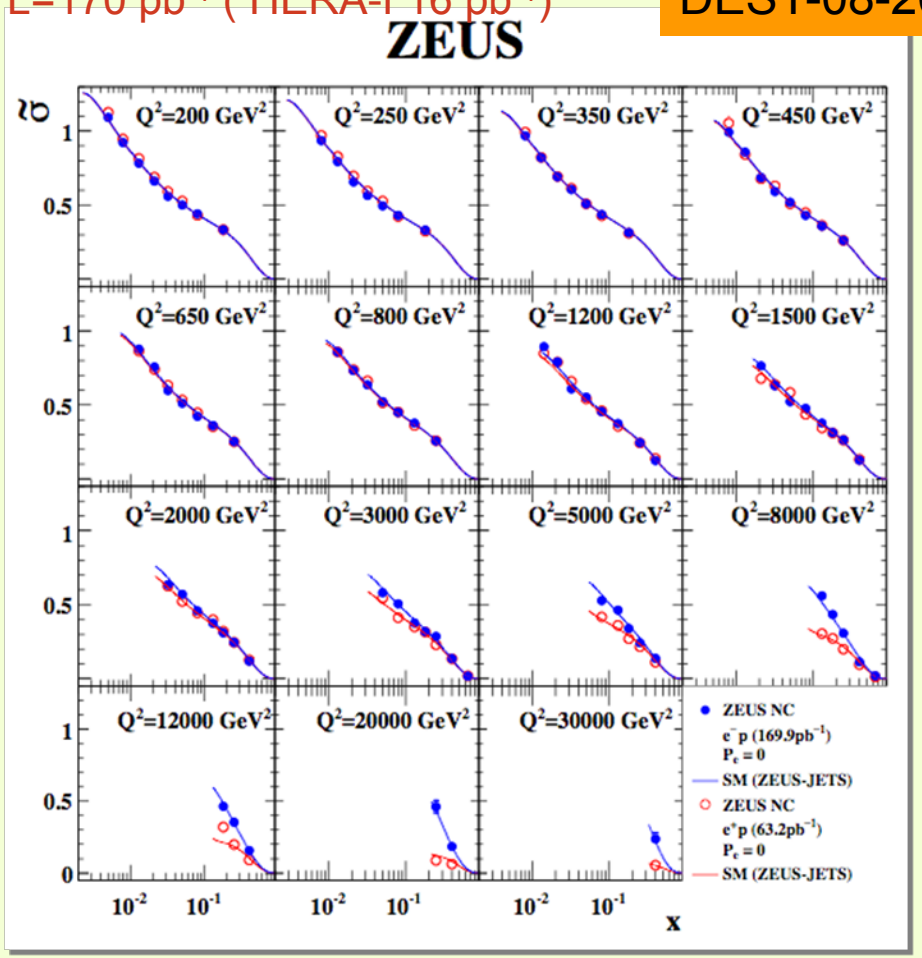

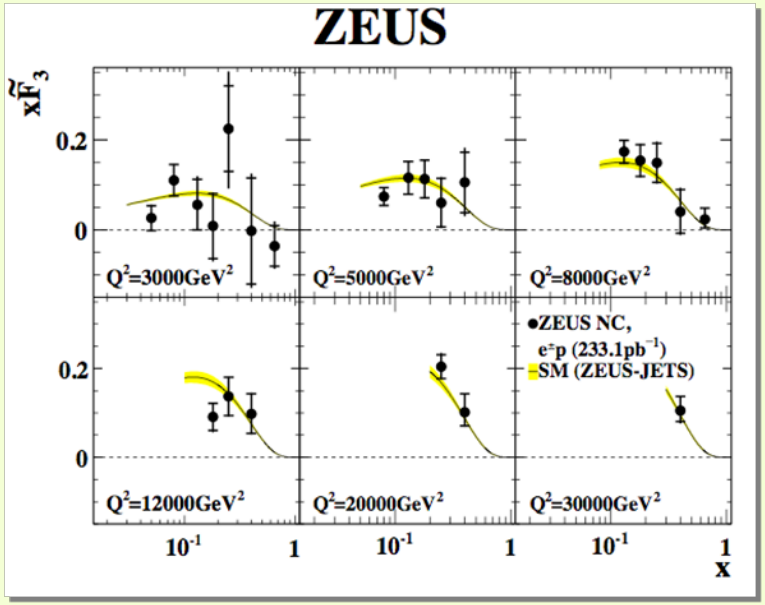

$$xF_3^{\gamma Z} = 2x[e_u a_u u_v + e_d a_d d_v] = \frac{x}{3}(2u_v + d_v)$$

$\Rightarrow$ Improve xu_v at high-x

see A. Cooper-Sarkar[59]

High Q^2 CC e^-p cross sections

$$\tilde{\sigma}(e^-p \to \nu_e X) = x\left[u + c + (1-y)^2(\bar{d} + \bar{s})\right]$$

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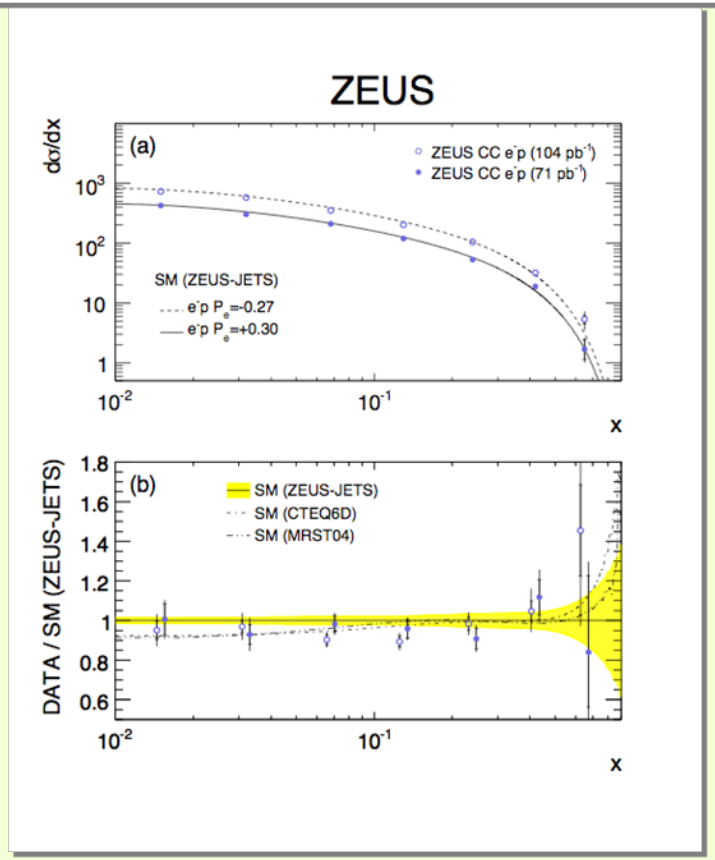
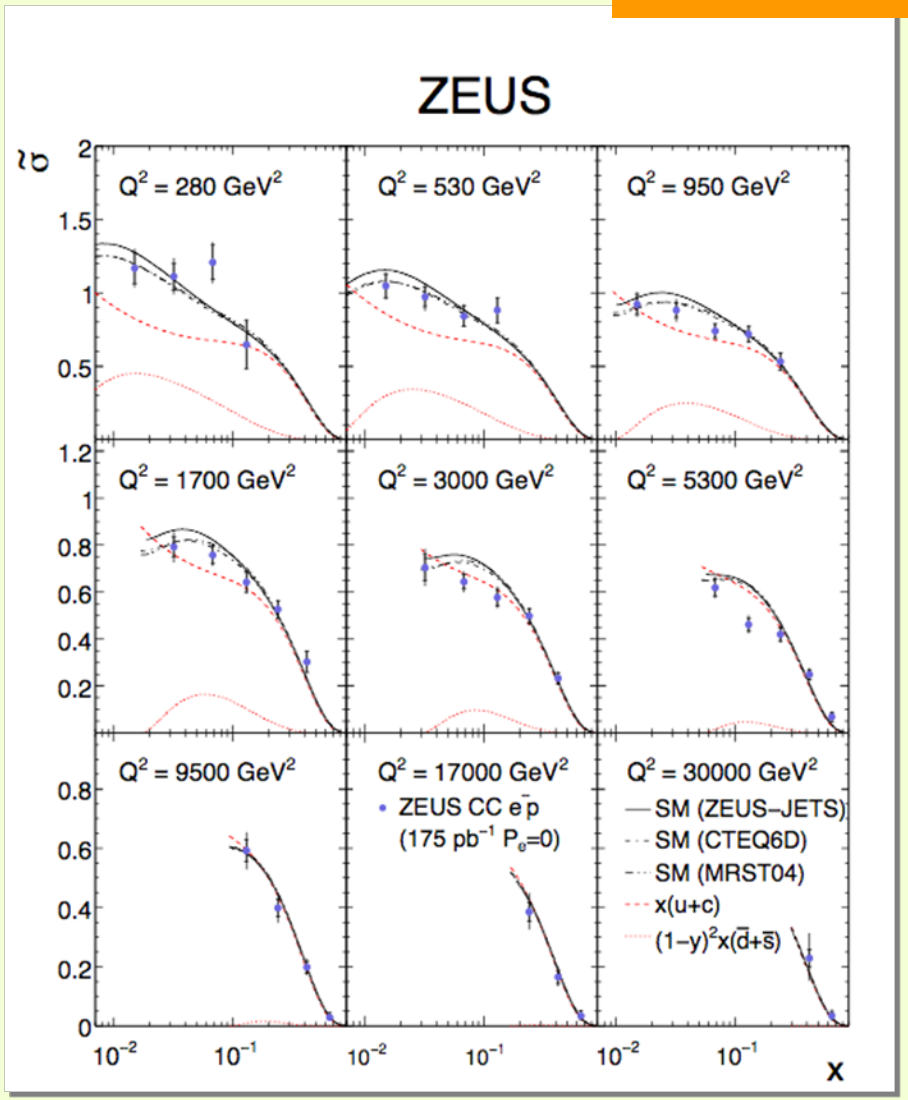
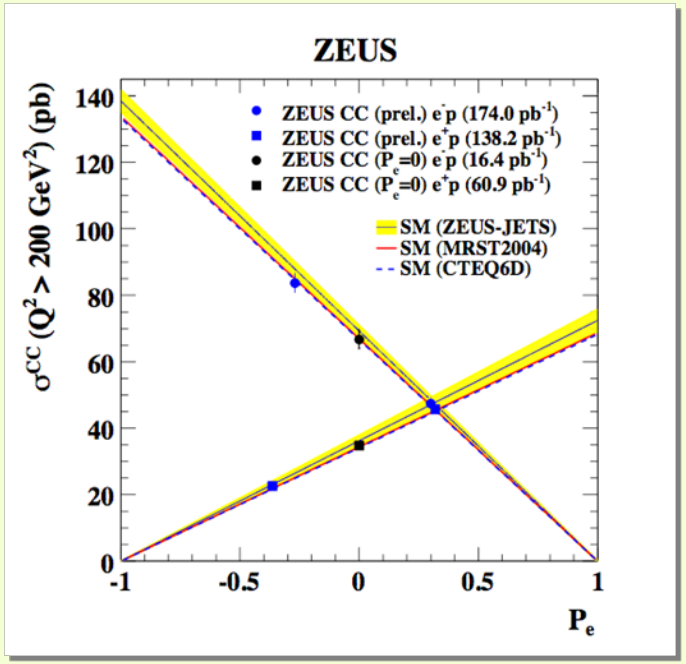




$\Rightarrow$ Improve xu_v at high-x

High Q^2 CC e^+p cross sections

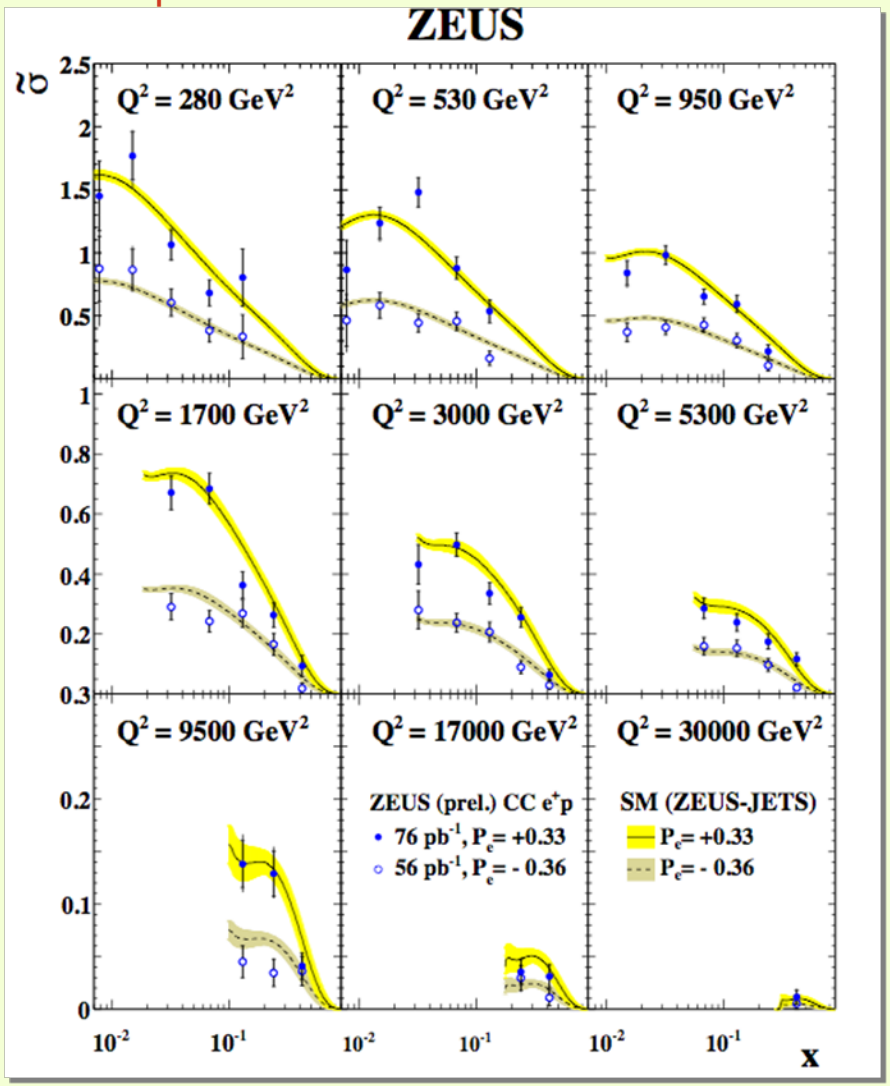


$$\tilde{\sigma}(e^-p \to \nu_e X) = x\left[(\bar{u} + \bar{c} + (1-y)^2(d+s)\right]$$

d-flavour sector less well-known

$\Rightarrow$ Important input to improve xd_v

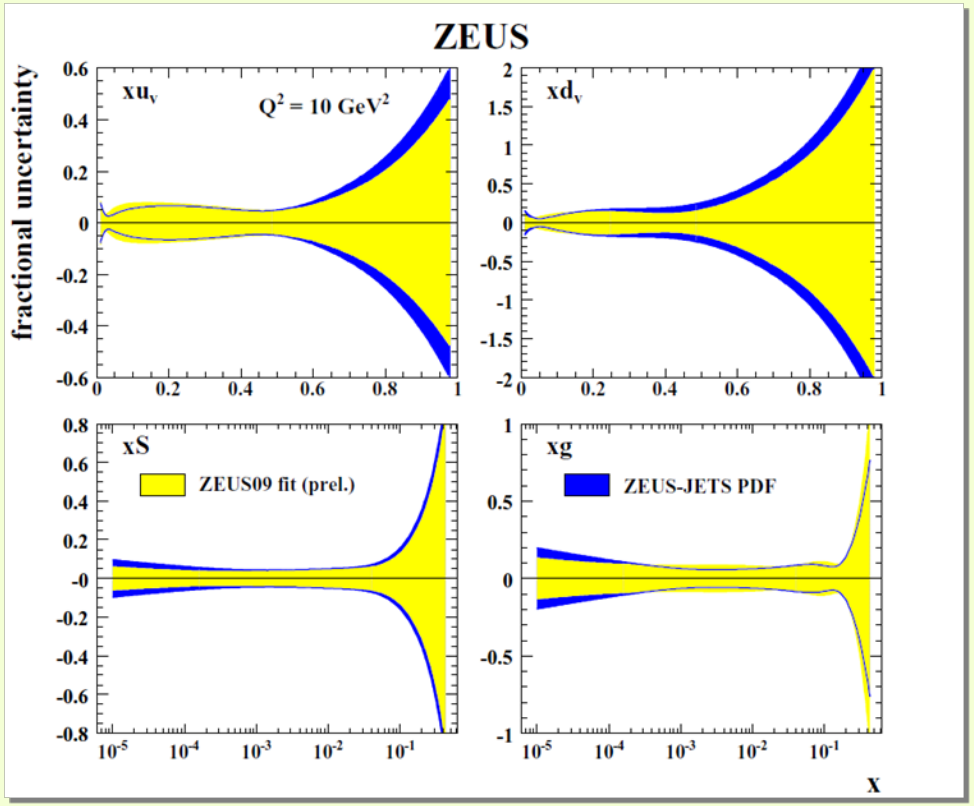
L=136 pb^{-1}

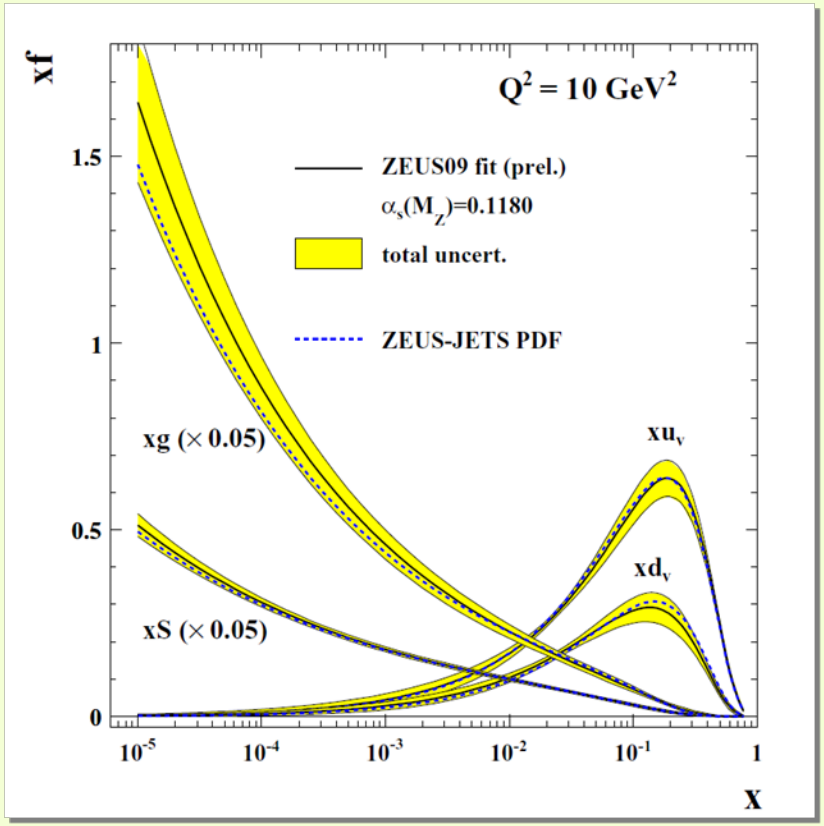


Zeus 2009 Fit

Use same approach as for the published ZEUS-JETS Fit to assess the impact of the new data:

CC $e^{\pm}p$, NC $e^{-}p$ and NC $e^{+}p$ H/M/LER

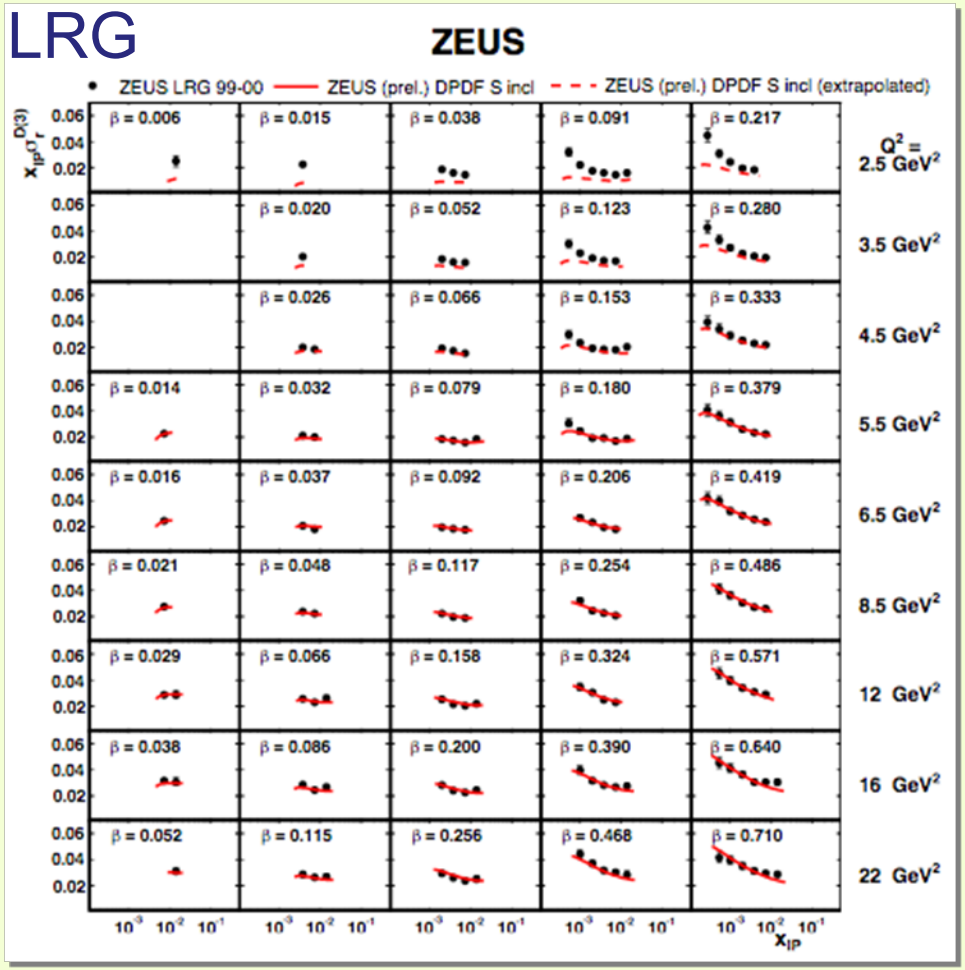




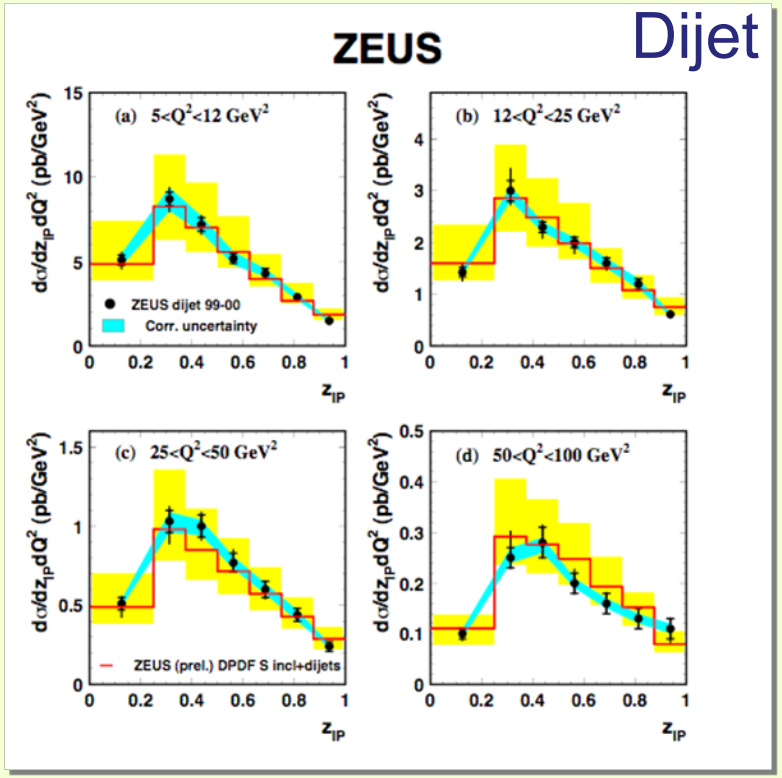
- improve unc. on xu_v, xd_v
- slightly steeper gluon

see A. Cooper-Sarkar[59]

Diffractive fit and dPDFs



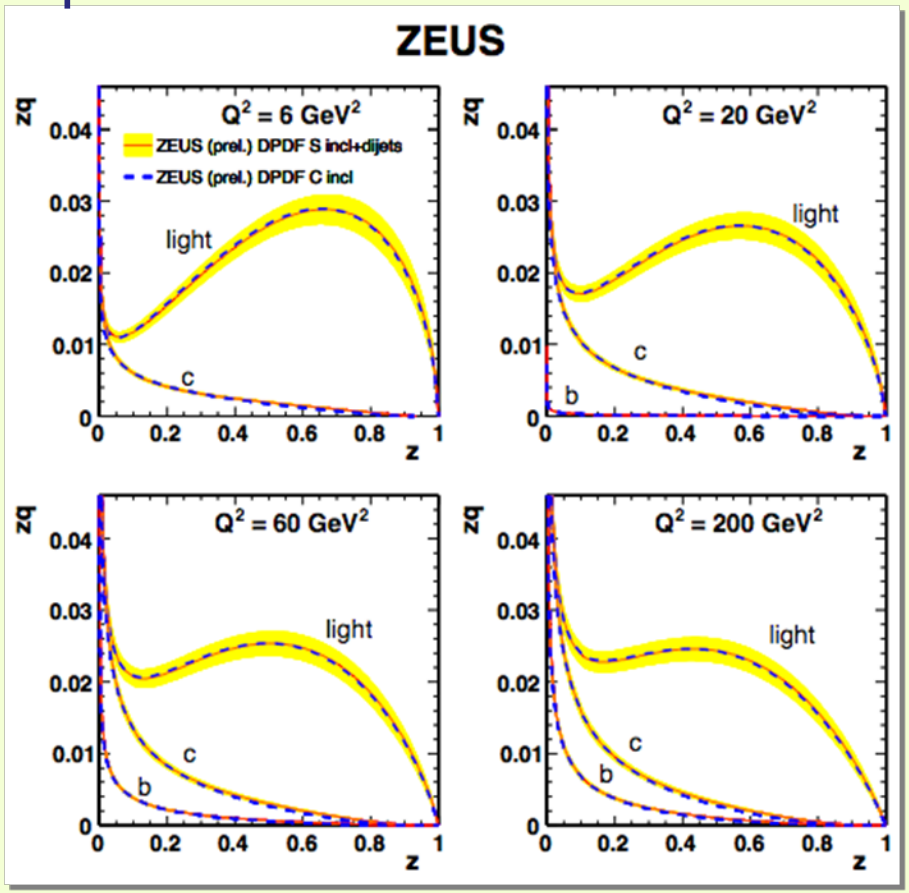
- NLO QCD fit to incl. DIS data
- Comparison and fit to dijet in DIS
- Comparison to dijet in PHP
- Heavy Flavours (Roberts-Thorne)



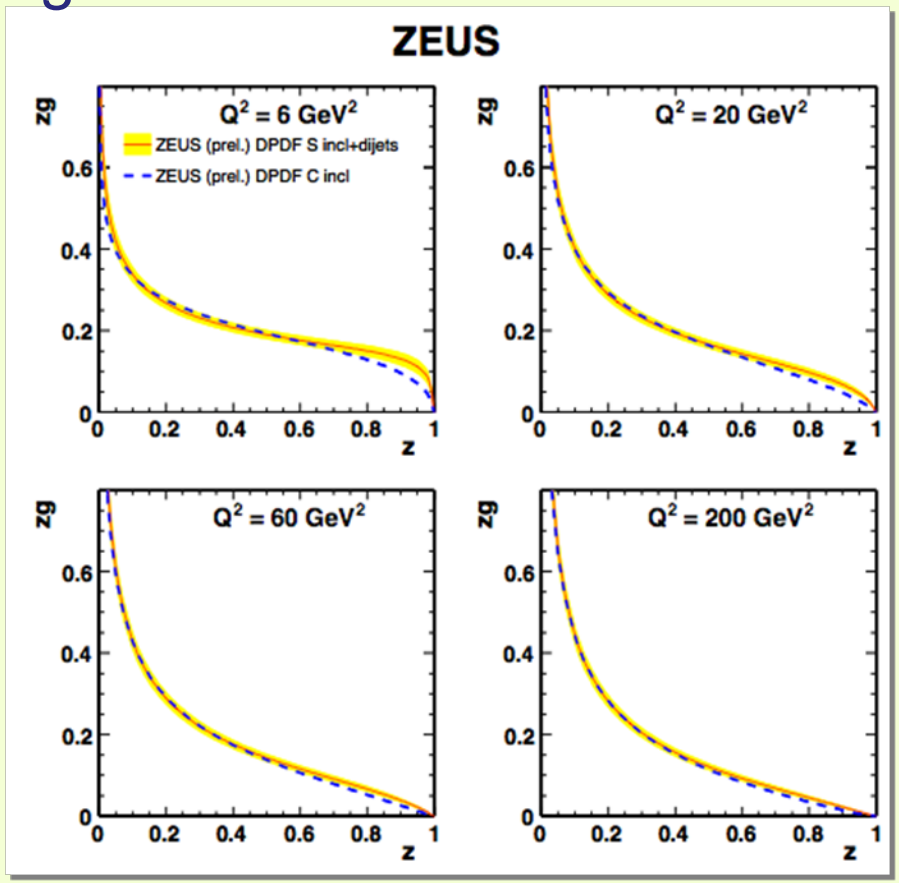
see W. Slominski[121]

Diffractive fit and dPDFs

zq

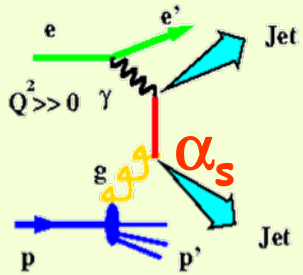


xg

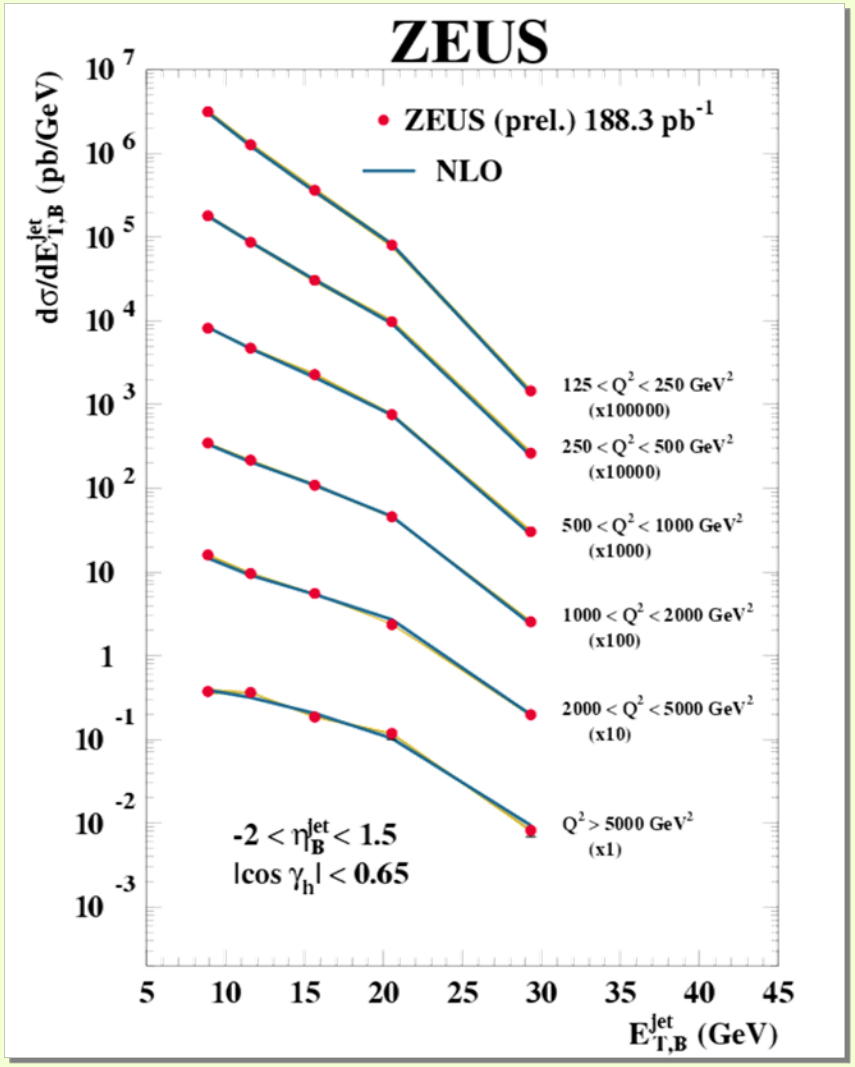


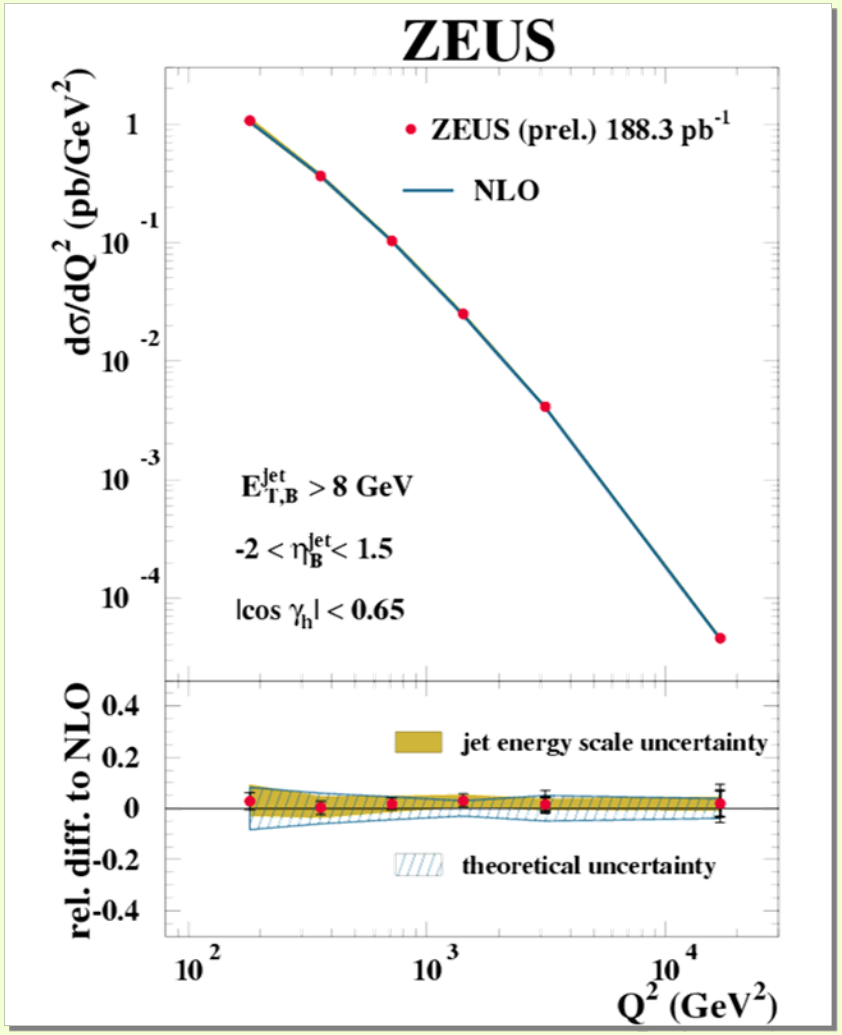
see W. Slominski[121]

Jet production in NC DIS



HERA-II e^-p





$\Rightarrow \alpha_s$ determination

Strong coupling

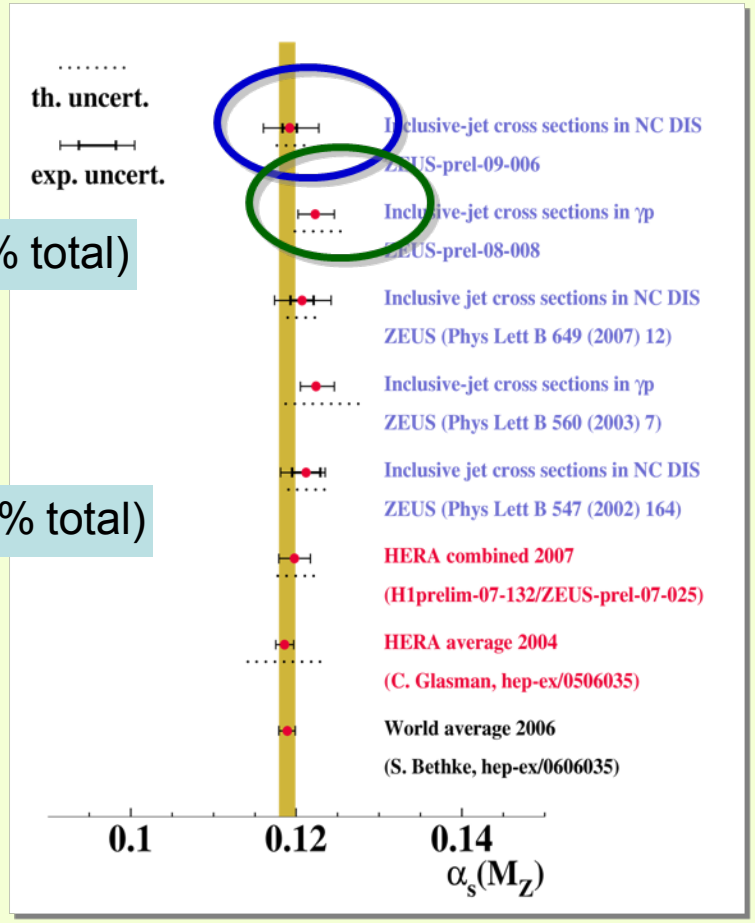
HERA-II NC DIS inclusive jets

(first determination from ZEUS with HERA-II data):

$$\alpha_s(M_Z) = 0.1192 \pm 0.0009\,(\text{stat.})^{+0.0035}_{-0.0032}\,(\text{exp.})^{+0.0020}_{-0.0021}\,(\text{th.})\ \ (3.5\%\ \text{total})$$

Re-analysis of HERA-I γp incl. jets:

$$\alpha_s(M_Z) = 0.1223 \pm 0.0001\,(\text{stat.})^{+0.0023}_{-0.0021}\,(\text{exp.})^{+0.0029}_{-0.0030}\,(\text{th.})\ \ (3.1\%\ \text{total})$$



- Improved exp. unc. from full HERA data
- <u>Need NNLO</u>

see C. Gwenlan[238]

Subjets

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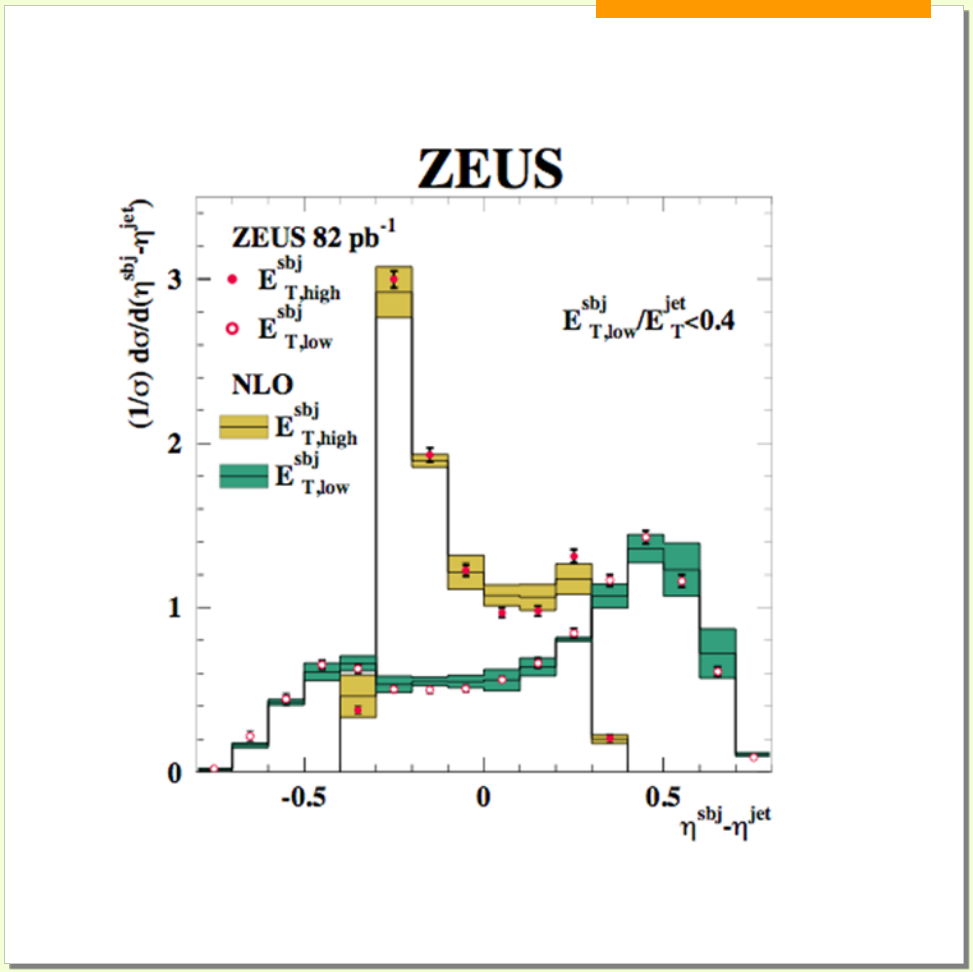


Study transition parton ⇒ hadrons

Two resolved subjets (y_{cut}=0.05):

- Highest E_T jet closer to the jet axis
- Lowest E_T jet towards p-beam direction

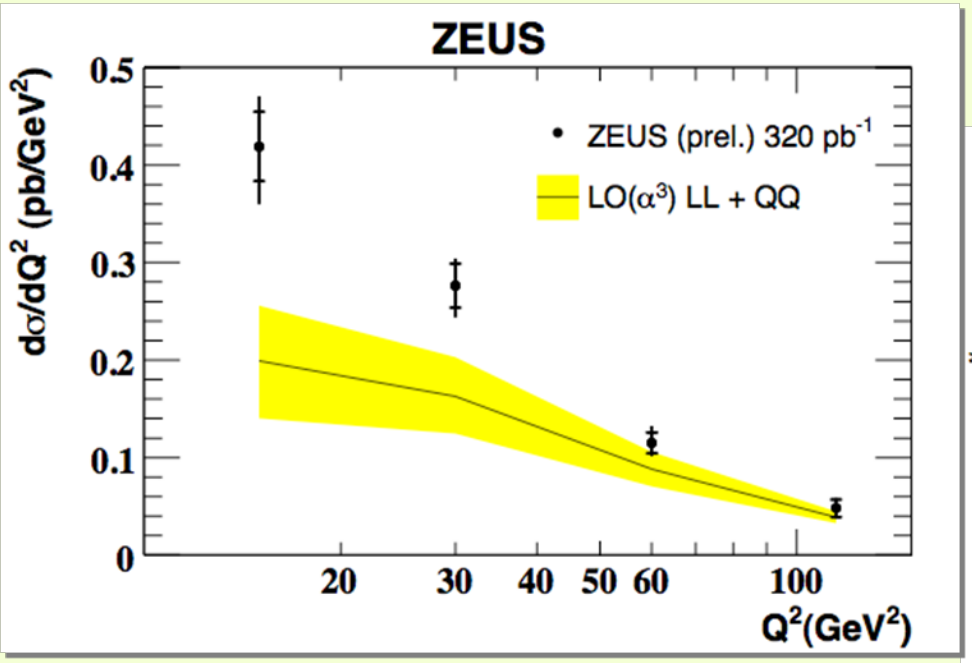
New for DIS2009:

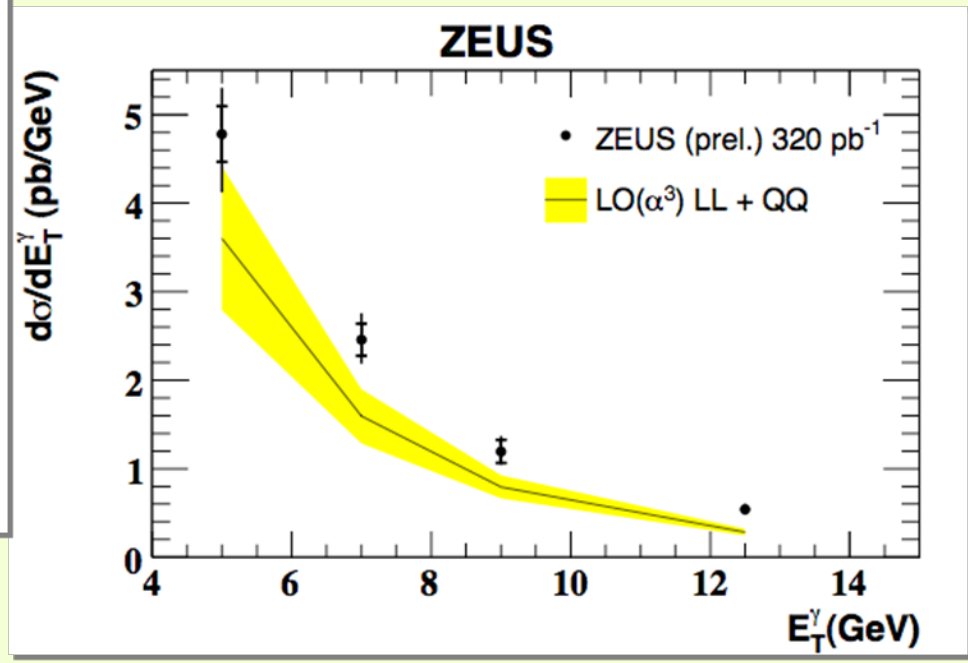
Three resolved subjets (y_{cut}=0.03)

(L=334 pb^{-1})

see E. Ron[240]

Prompt-photon production

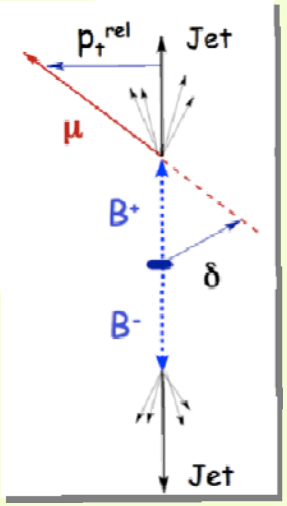


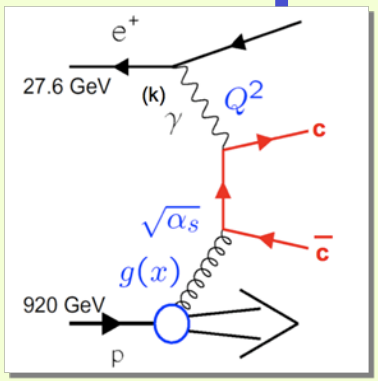


- Large statistics
- Only LO predictions available

see M. Forrest[282]

Semileptonic Charm and Beauty





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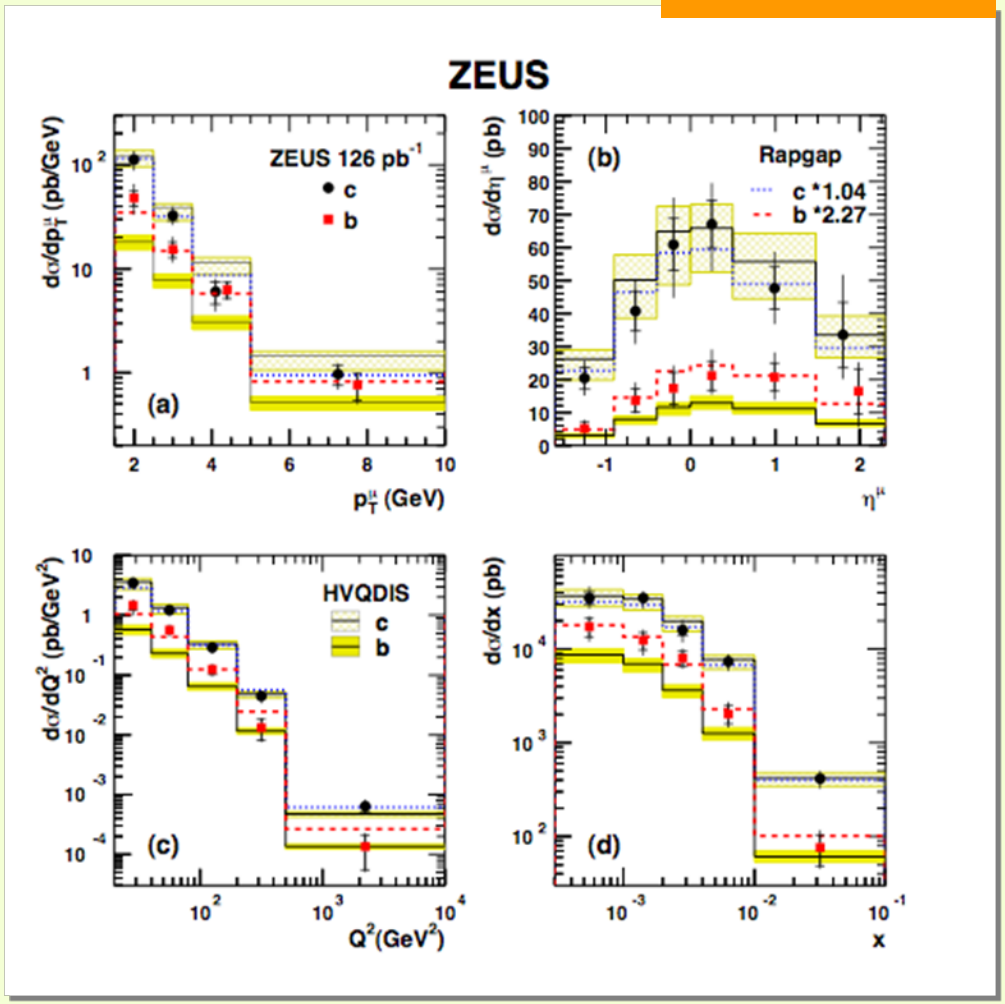


HERAII e^-p (2004/05) 126 pb^{-1}

$Q^2 > 20$ GeV^2

c, b and lf fractions extracted from a simultaneus fit of 3 discriminating variables:

P_T^{rel}, δ, $p_T^{miss||\mu}$

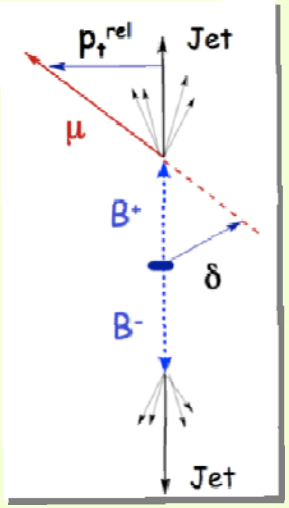
Theory : FFNS NLO (HVQDIS)

Charm : Good description

Beauty: Excess at low Q^2 (~2 σ)

see P. Roloff[168], M. Bindi[179]

Beauty in Photoproduction



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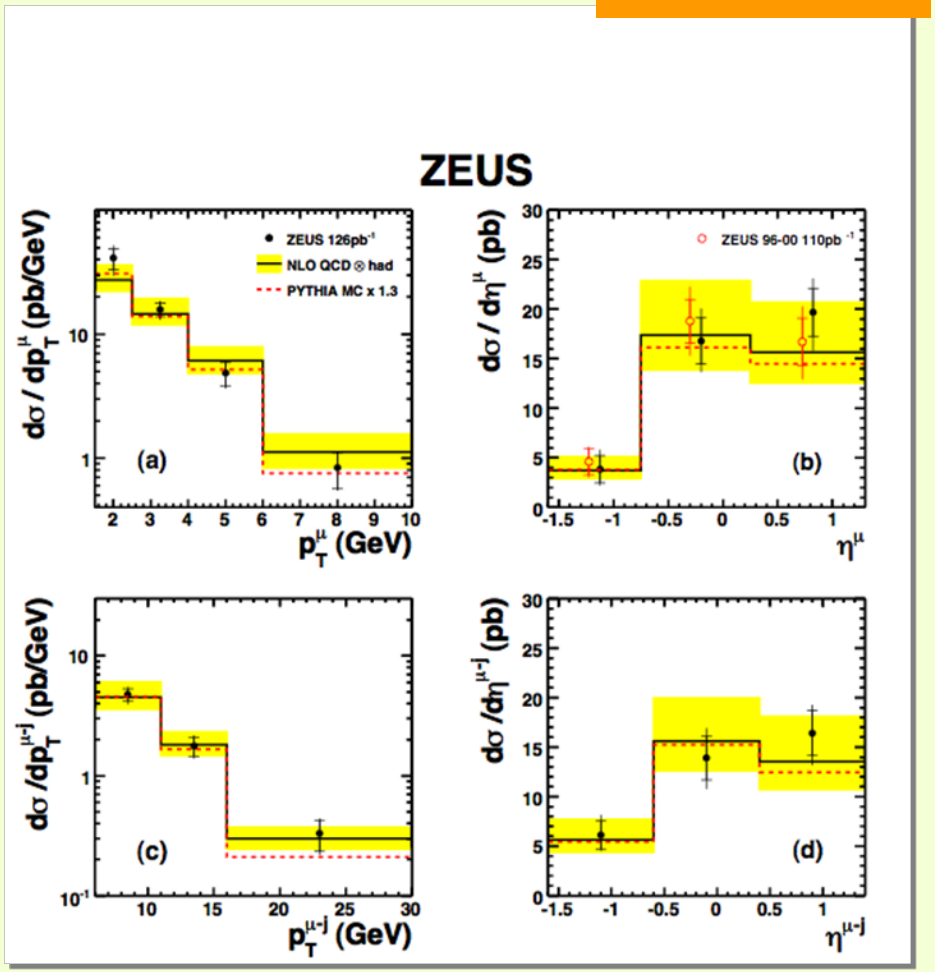


HERA II data (05 e^+p) 125 pb^{-1}

Look for b in two jets events with high-pt lepton

Kt clust:

$N_{jet} \geq 2$, $P_t > 7(6)$ GeV , $|\eta| < 2.5$

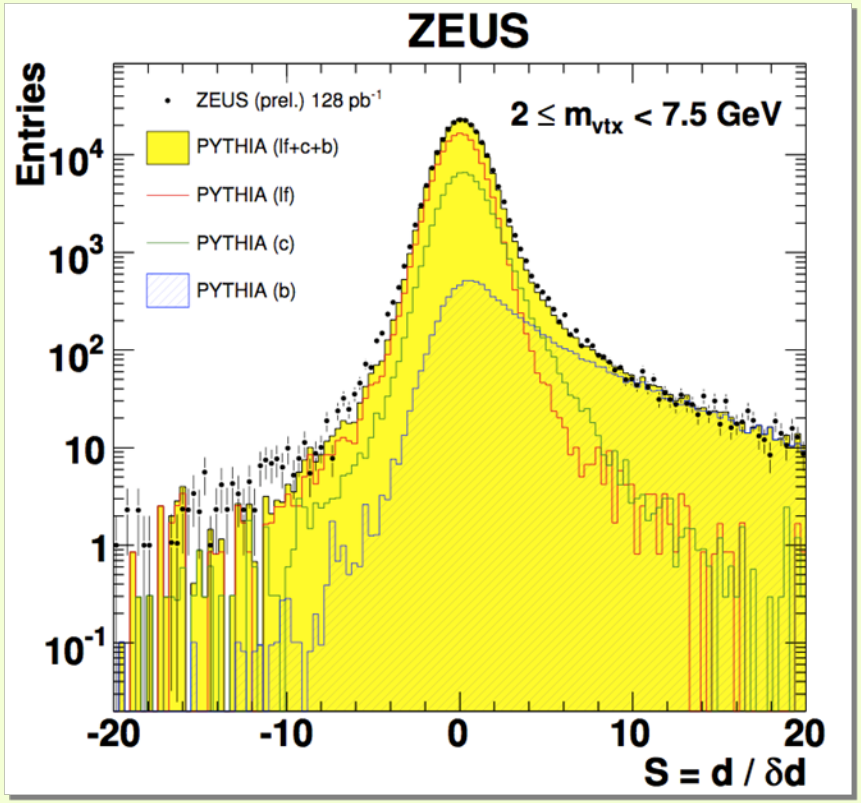
Theory: FMNR

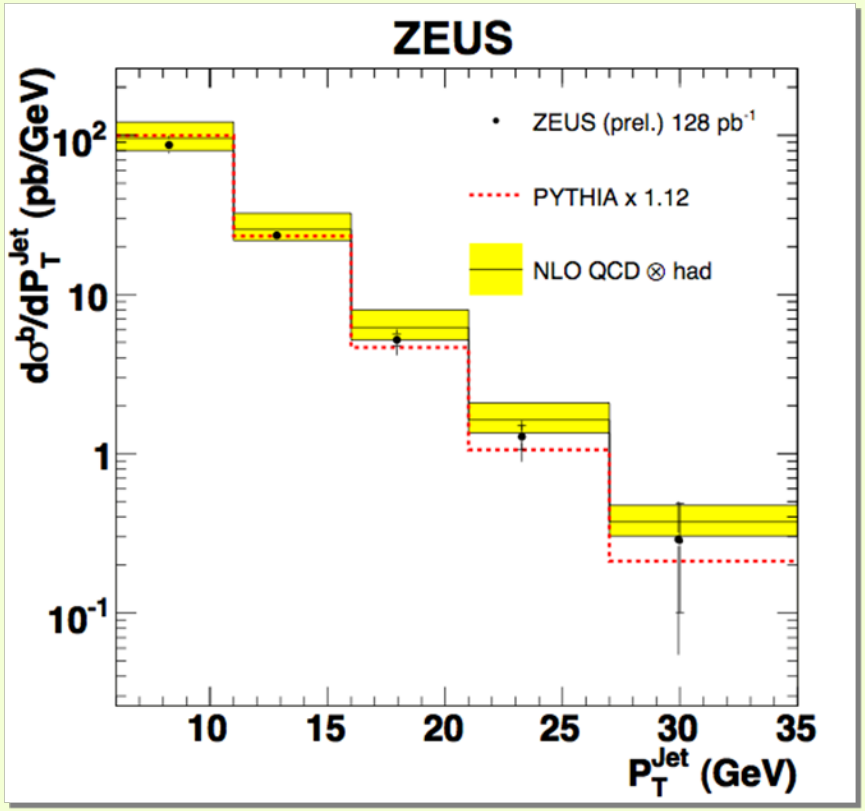
Good agreement with NLO QCD

Beauty in Photoproduction

Lifetime tagging: Fraction of b from decay length significance

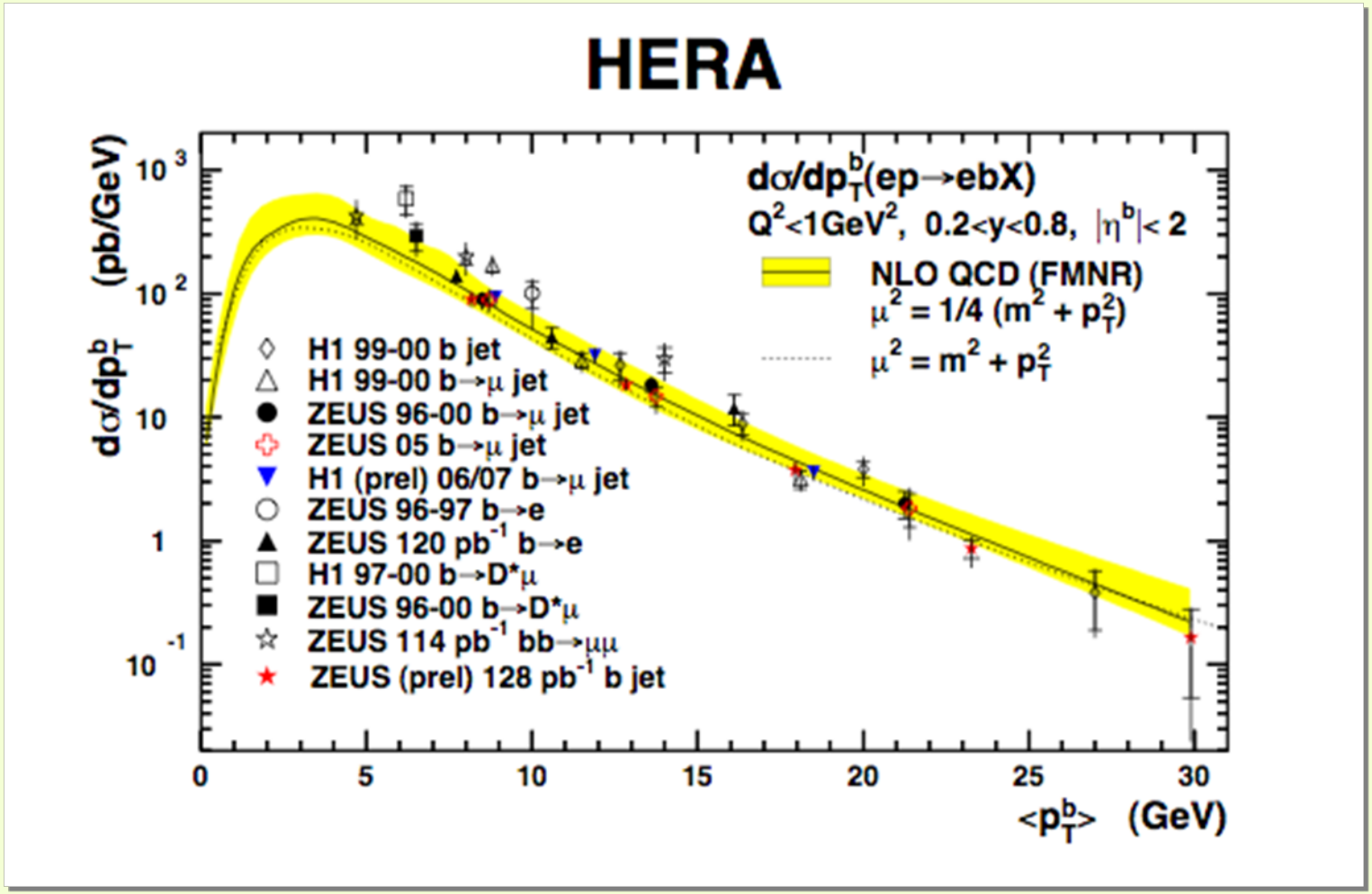
Good agreement with NLO QCD





see S. Miglioranzi[120]

Beauty: Summary plot



Summary

- Inclusive Measurements and Proton Structure
  - Steady progress in the H1/ZEUS combination
  - First F_L measurement from ZEUS completed
  - Huge effort to complete high-Q^2 cross sections

    => impact on the new ZEUS PDFs
- Exclusive processes and pQCD
  - New precise results on Jet and heavy quarks production
  - We need better theory here

It has been a productive year for ZEUS
(18(6) papers 2008(9), 20 presentations to this Workshop)
But a lot of work (and fun!) analyising HERA II data is still waiting us…