Structure Functions and Parton Densities Working Group

- Experimental Summary -

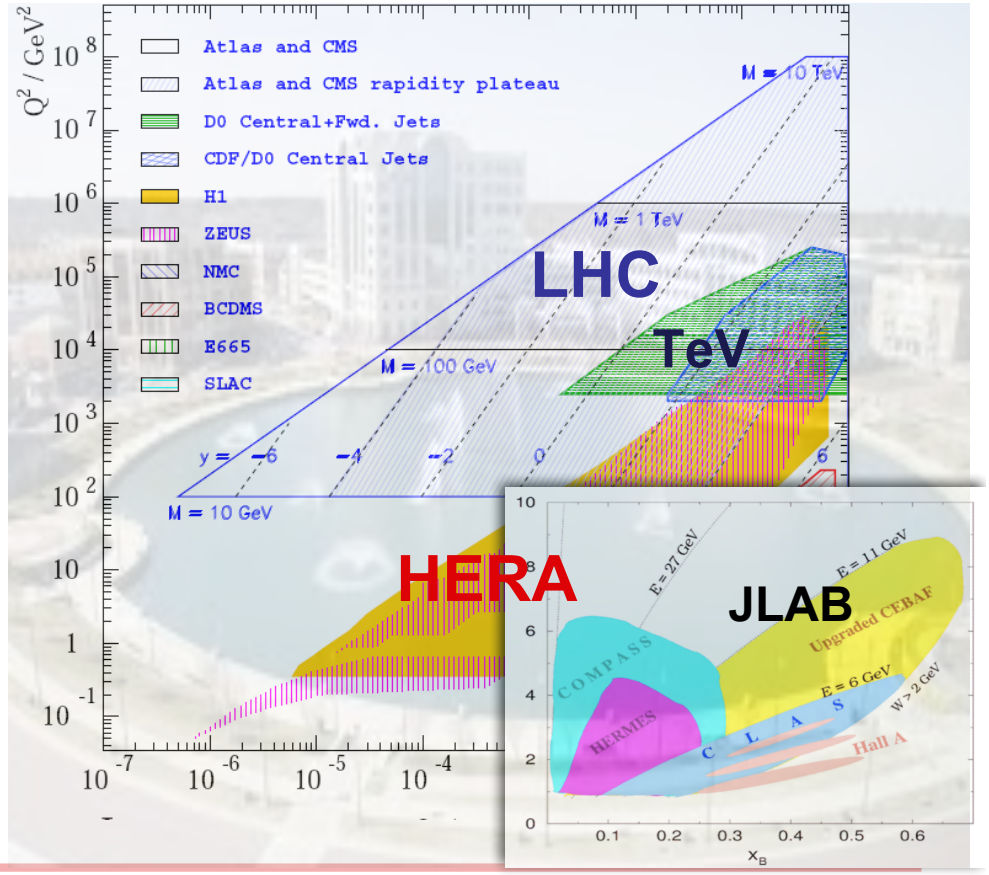
XIX International Workshop on Deep-Inelastic Scattering and Related Subjects

Voica Radescu, Jolanta Sztuk-Dambietz, Maria Ubiali

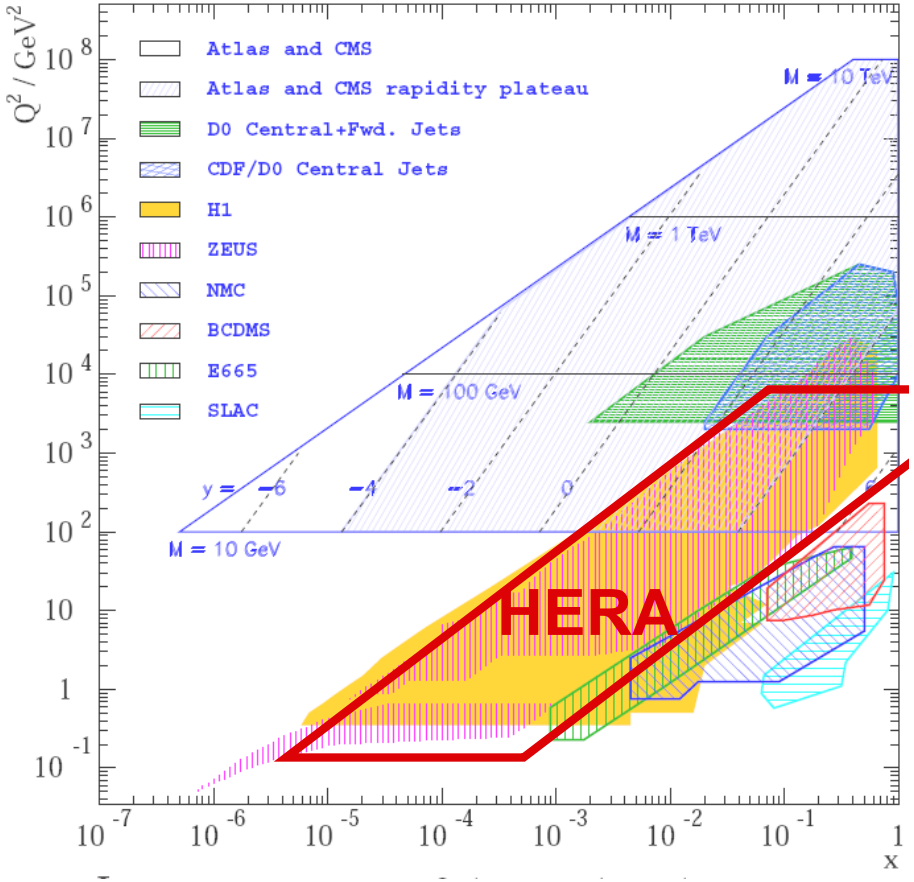
Very successful working group:

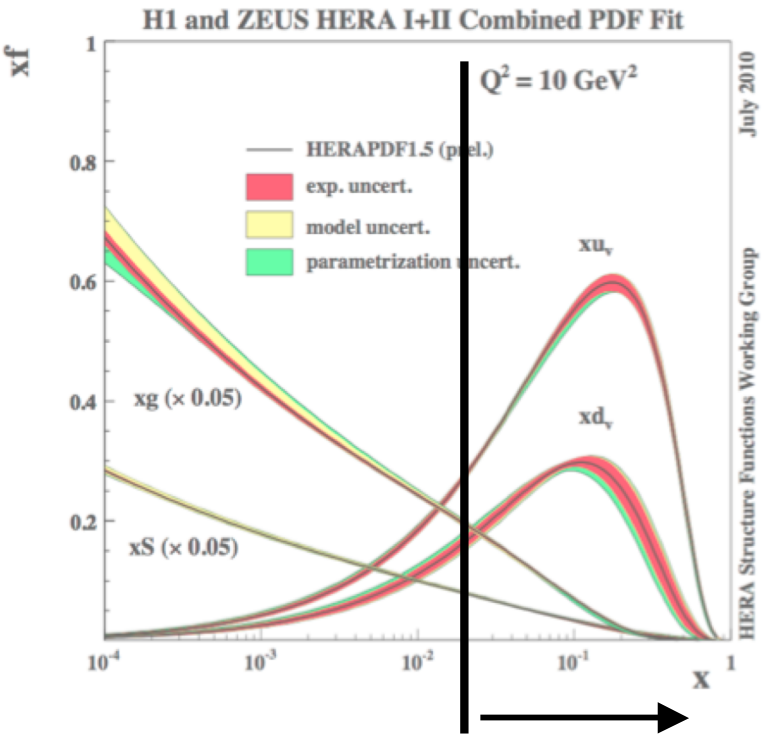
- 10 sessions with a total of 48 talks
  - 5 Structure Functions and PDF
  - 2 Joint with Electro Weak and BSM
  - 2 Joint with Heavy Flavour
  - 1 Joint with Low X

- Results from HERA, LHC, Tevatron, JLAB with the motivation to provide most accurate measurements of the proton structure.



New Measurements from ep collider





- Dedicated measurements to improve precision at high x

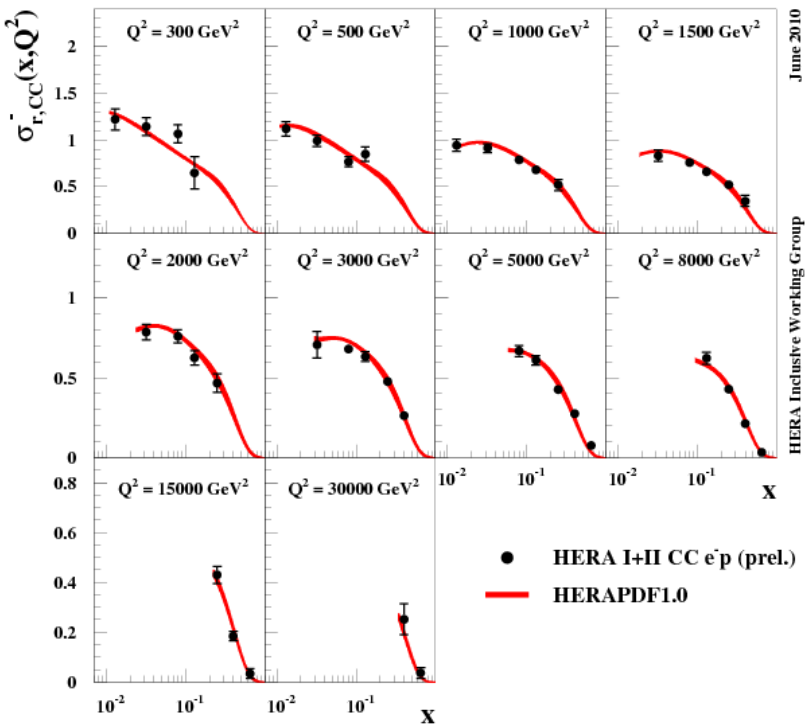
News from HERA – high Q^2 ➔ used in HERAPDF1.5

J. Sztuk-Dambietz

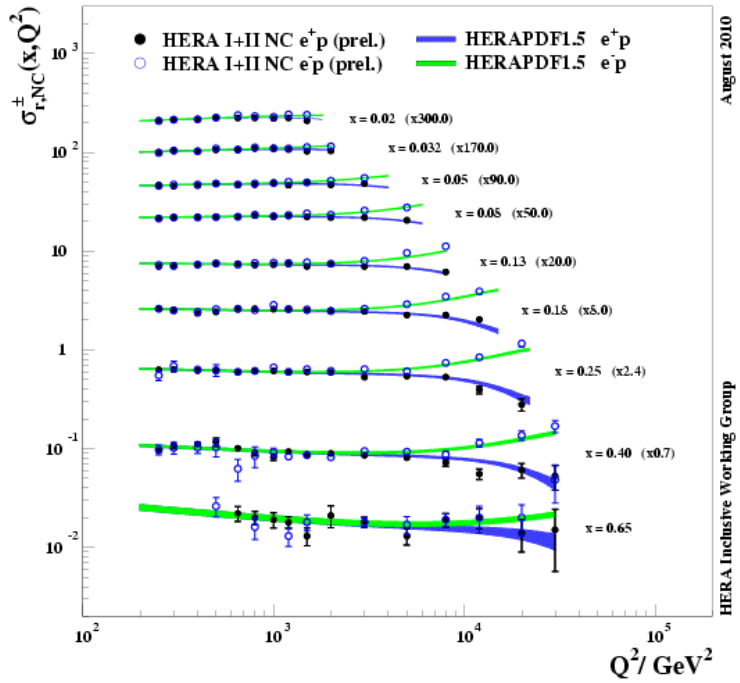
- Combined HERA I+II data as input for HERAPDFs

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

HERA-I+II e-p CC DIS vs. HERAPDF1.5



HERA-I+II NC DIS vs. HERAPDF1.5



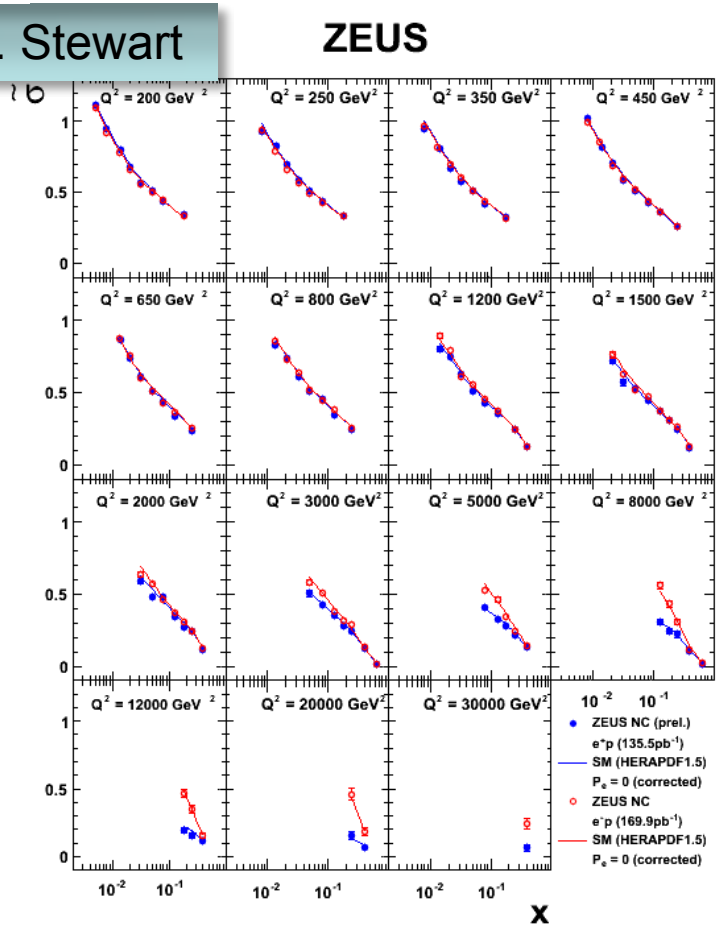
→improved precision in high x and high Q2 region → better constraint on valence PDFs

→These measurements are preliminary, but already used for HERAPDF1.5.

New data from HERA at high Q^2 and high-x → to be used

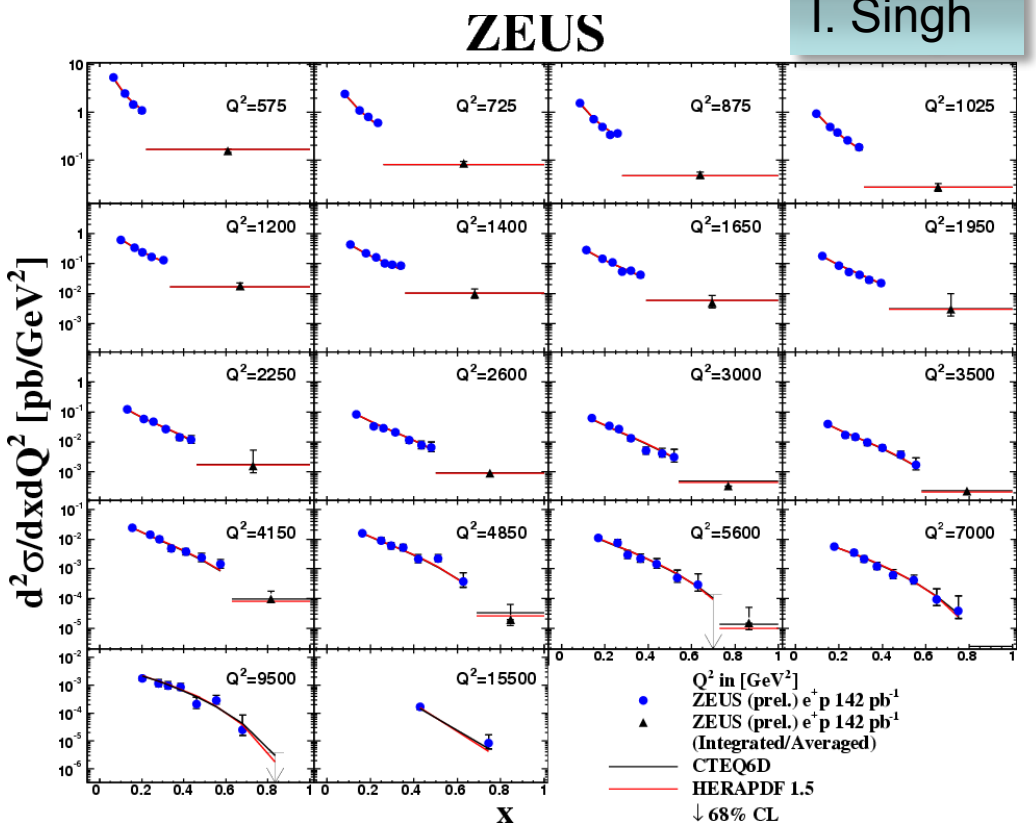
NC e+p DIS at high-Q^2

T. Stewart



NC e+p DIS at high-x

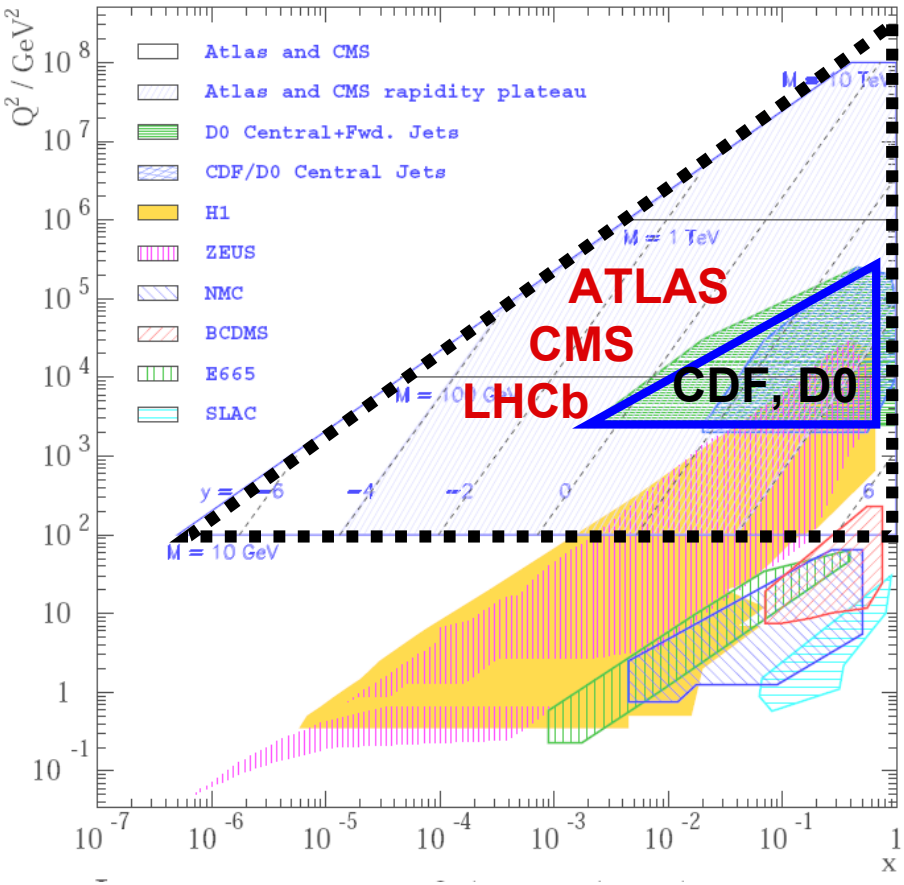
I. Singh

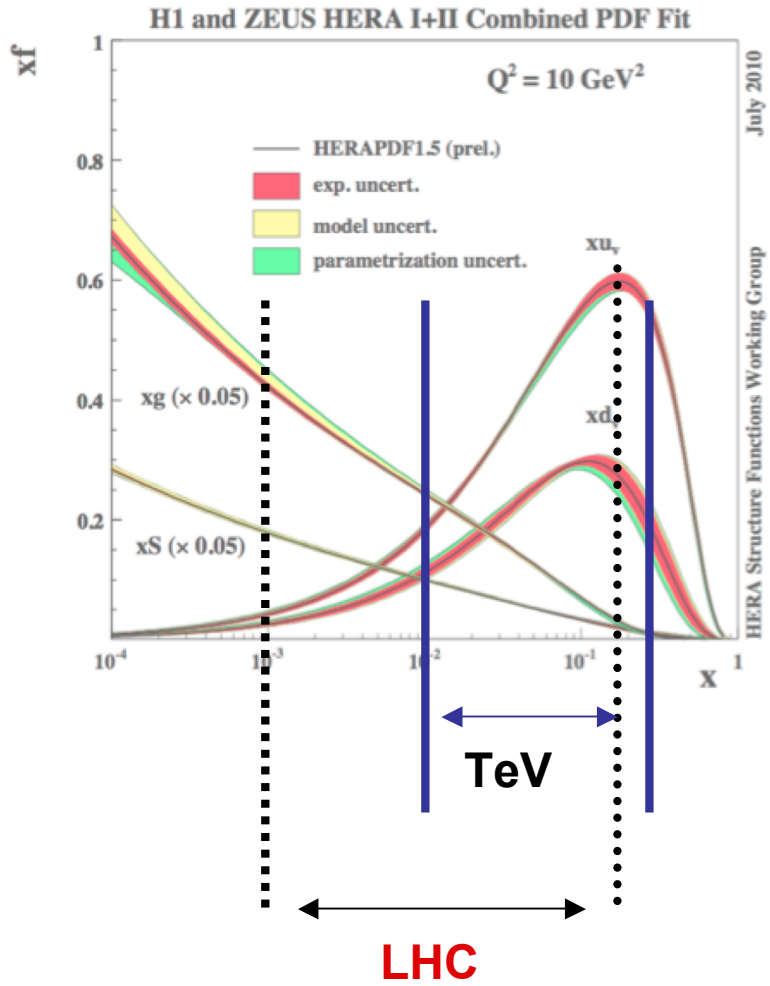


New x-reconstruction method for non-zero jets leading to better resolution

New data available to further constrain HERAPDF, especially at high x

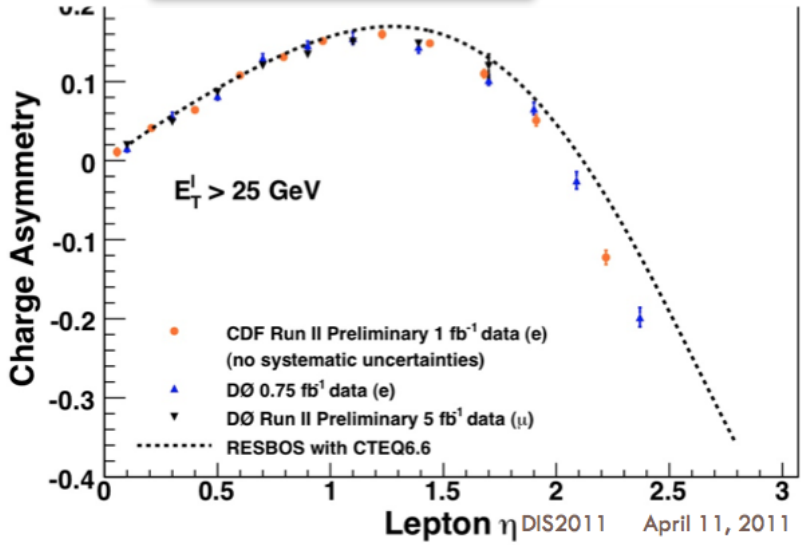
Contraints on PDFs from pp and ppbar colliders

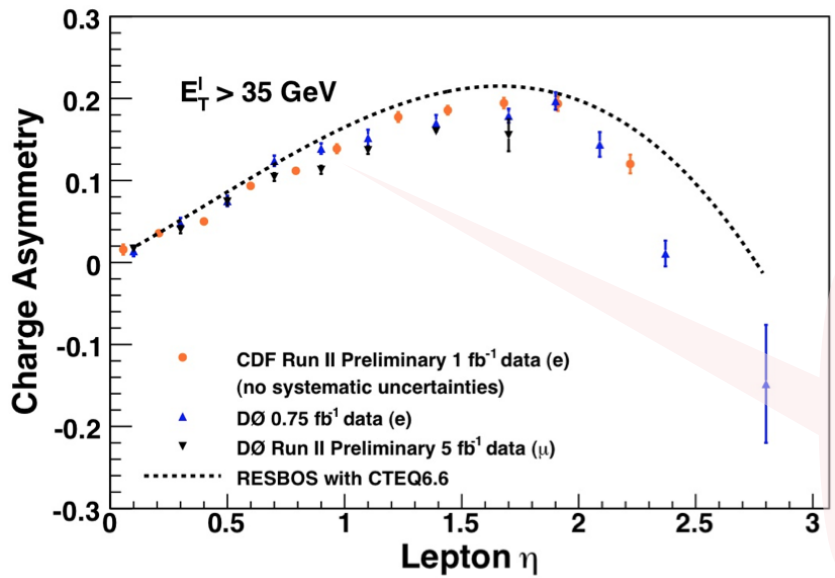




Interpretation of the W asymmetries from Tevatron

H. Schellman





- W asymmetry is sensitive to differences between u and d:

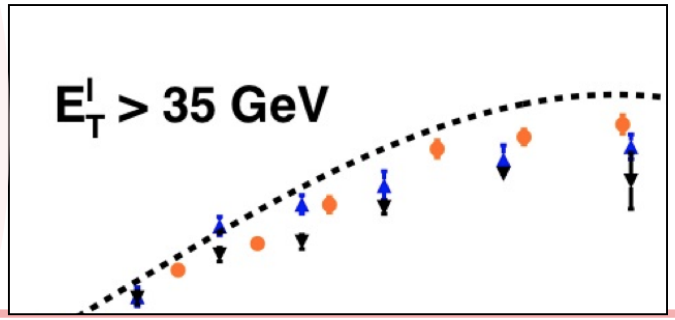
CDF:

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

D0:

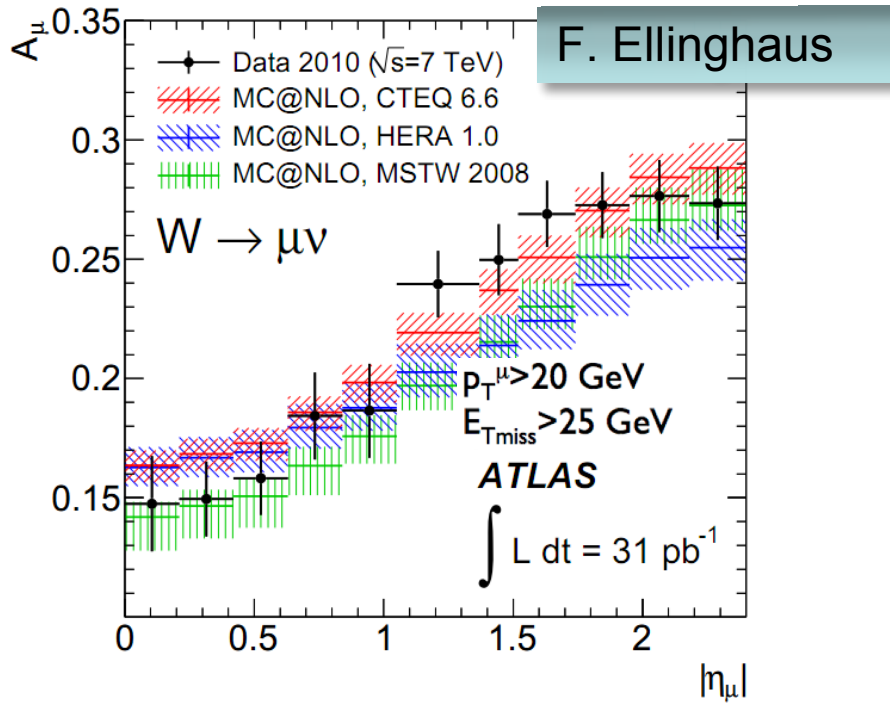
$$A(\eta_\mu) = \frac{\frac{d\sigma(\mu^+)}{d\eta_\mu} - \frac{d\sigma(\mu^-)}{d\eta_\mu}}{\frac{d\sigma(\mu^+)}{d\eta_\mu} + \frac{d\sigma(\mu^-)}{d\eta_\mu}}$$

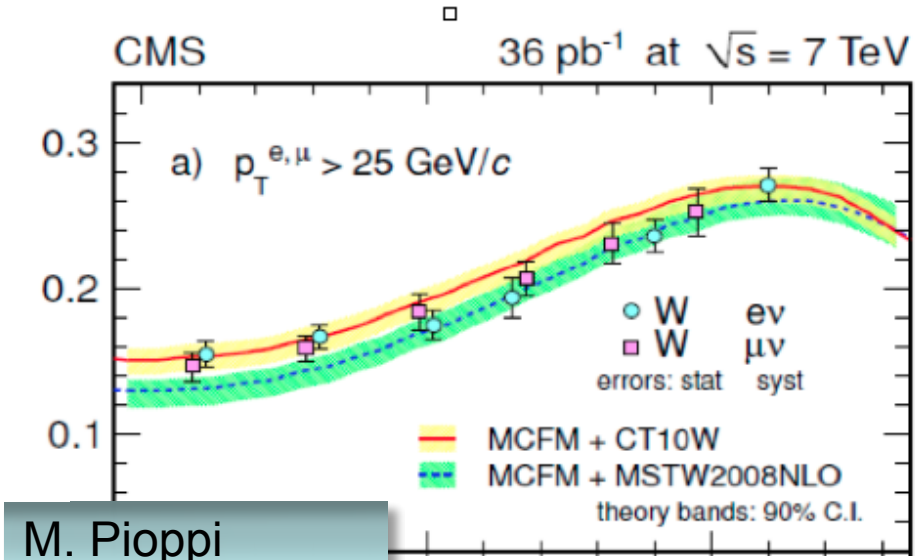
- Recommendation:
  - Use most inclusive measurements for fits (not binned in Pt bins)
- Claim is that CDF and D0 agree very well, however this is <u>still arguable:</u>
  - Run I vs Run II differences?

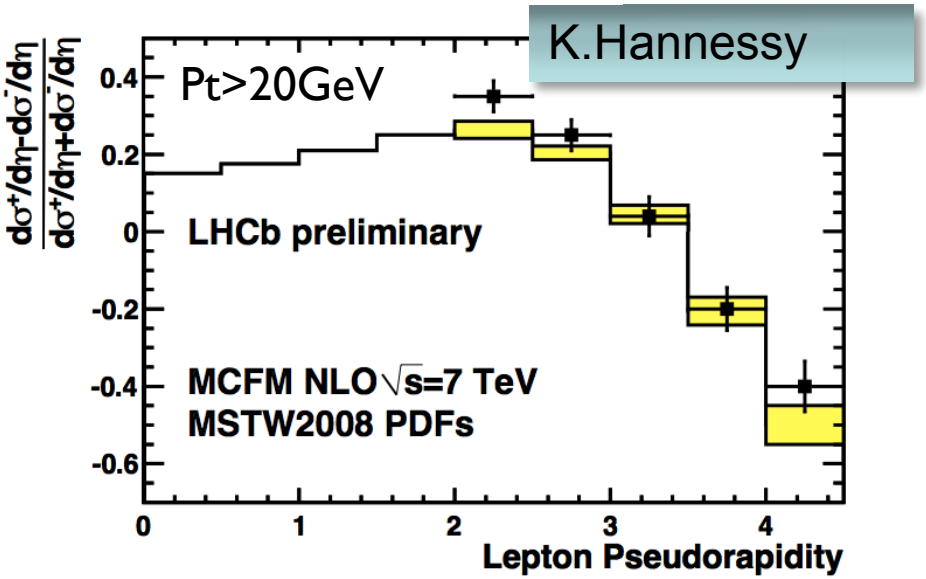


Constraints on proton knowledge from LHC

- W lepton charge asymmetry can be measured by all experiments at the LHC:
  - **ATLAS:** 31/pb, only muon channel
  - **CMS:** 36/pb, muon and electron channels
  - **LHCb:** 16/pb, no EW corrections
  - For direct comparisons of these measurements:
    - **Use similar Fiducial volume**
    - **EW corrections**





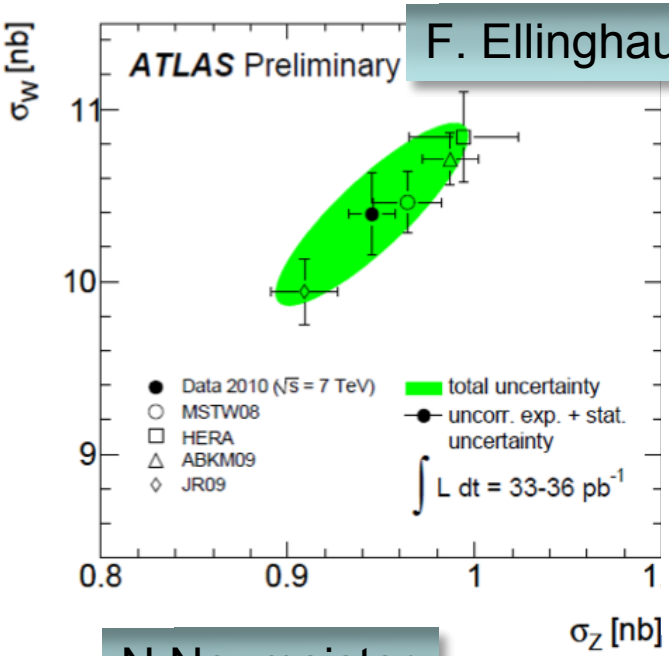


Other measurements from the LHC to constrain PDFs

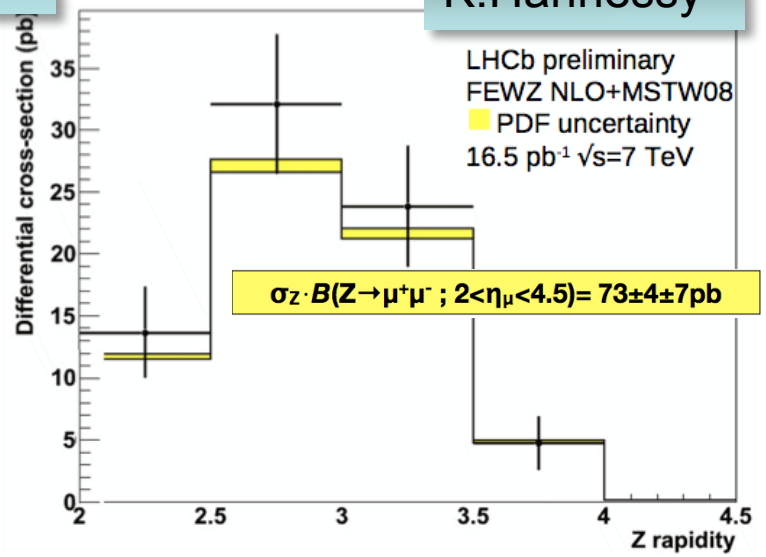
- Inclusive W and Z cross sections from ATLAS and LHCb

- To separate ubar and dbar for the same (Q^2,x) region a good observable is the Drell-Yan differential cross section normalized to the Z peak:
  - Good agreement is found with theoretical predictions
  - However….

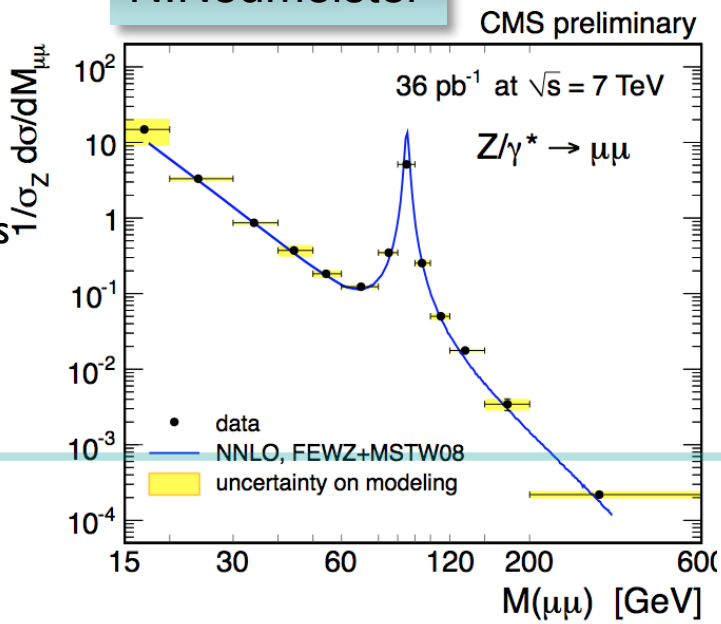
F. Ellinghaus



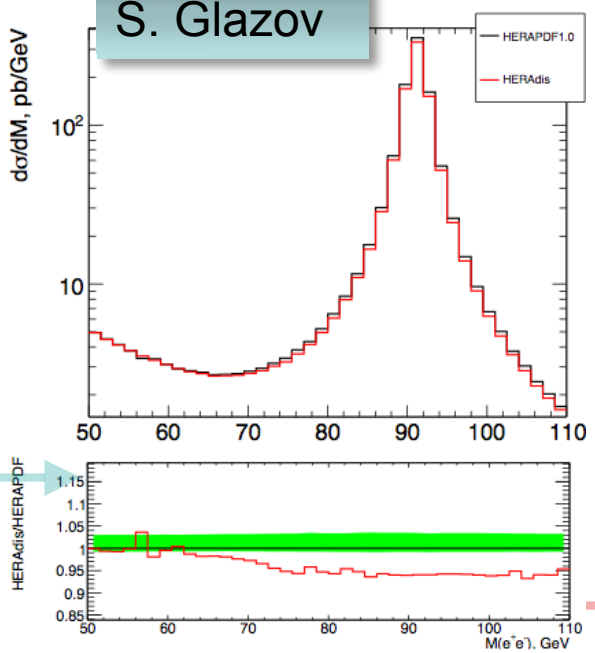
K.Hannessy



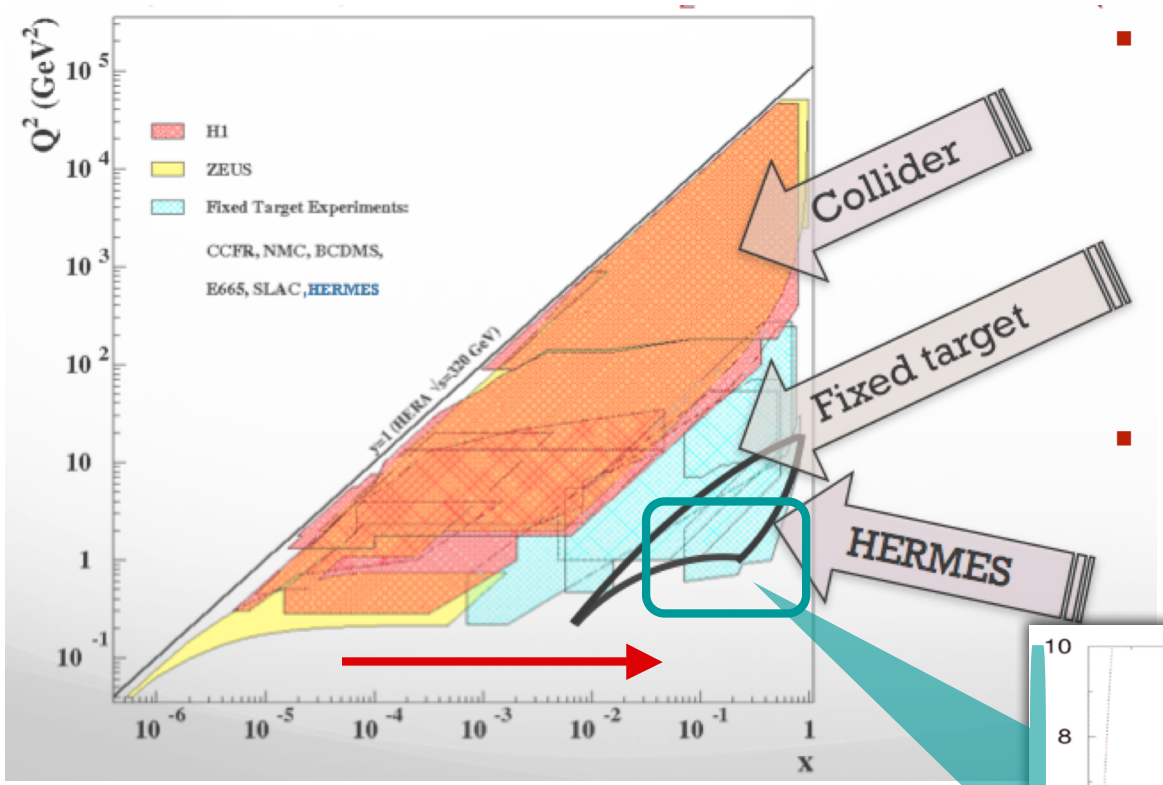
N.Neumeister



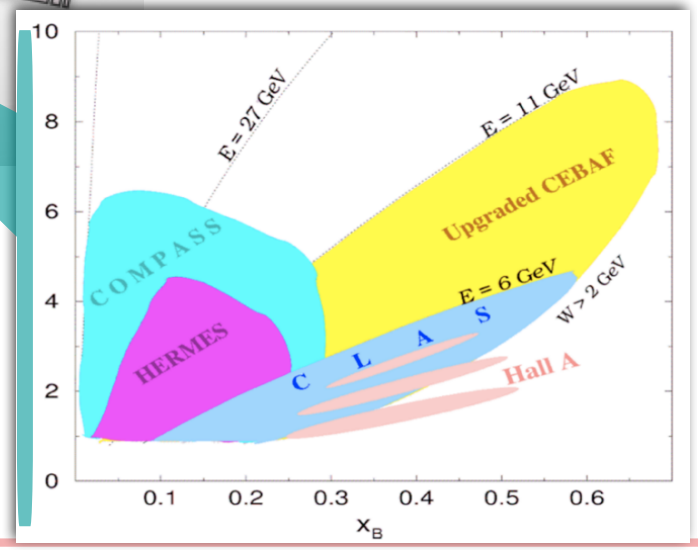
S. Glazov



Structure Functions from low to high x



- Longitudinal structure function sensitive:
  - to gluon density
  - to power corrections in Q^2
  - to higher twist contributions
- Exploit the difference between proton and deuteron structure functions, sensitive to d/u.



New Measurement of F_L from H1

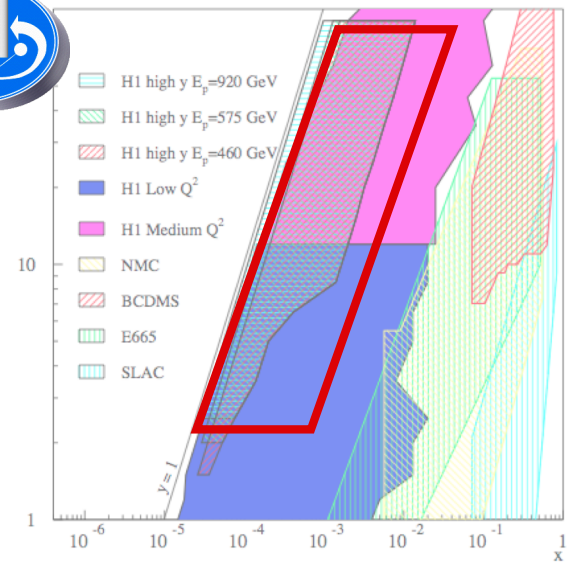
NC Reduced cross section: $\sigma_r(x,Q^2)$

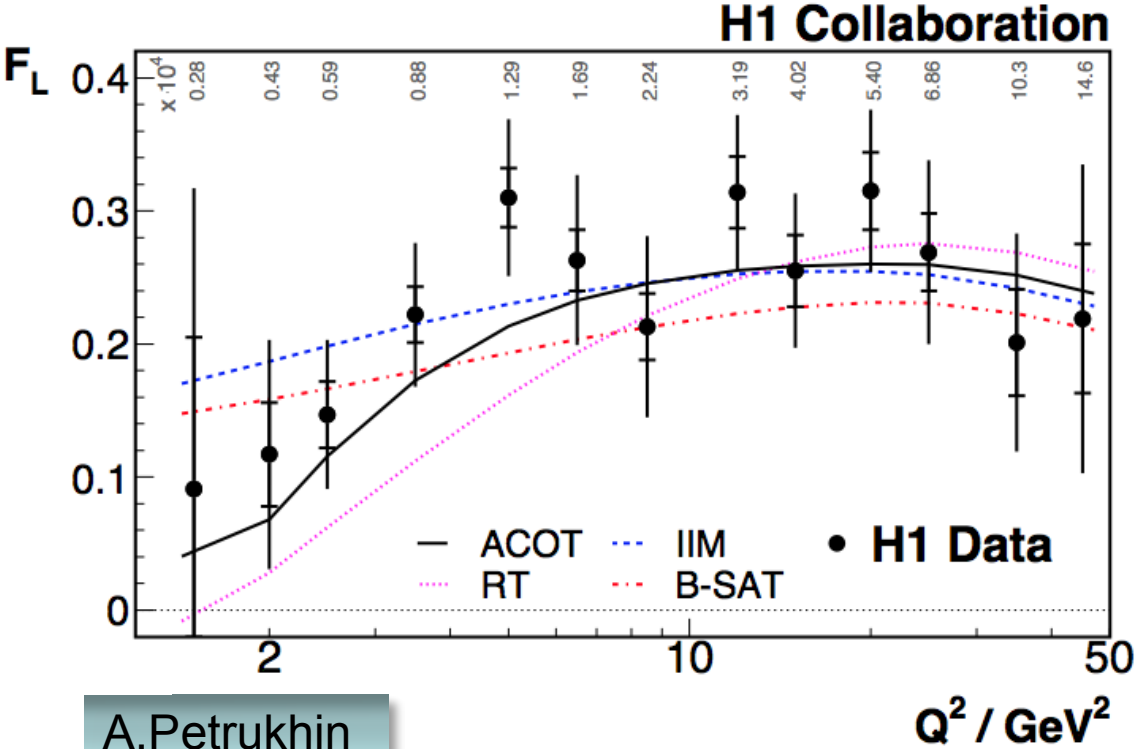
$$\frac{d^2\sigma_{NC}(e^{\pm}p)}{dx\,dQ^2} = \frac{2\pi\alpha^2}{xQ^4} Y_+ \left[F_2 - \frac{y^2}{Y_+} F_L \right]$$

Dominant contribution

Sizeable only at high y (y > ~0.6)

- Different CME to measure both *F2* and *FL*

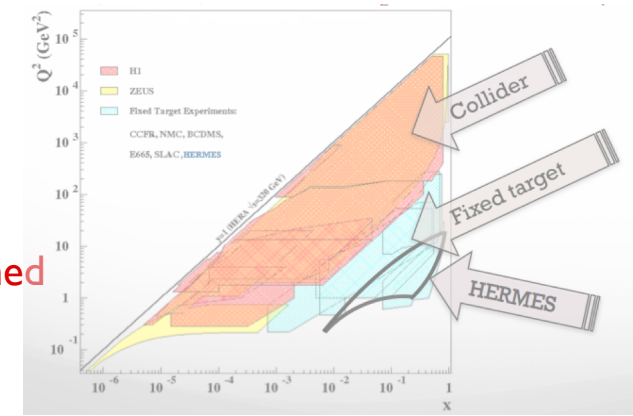




A.Petrukhin

- New data extends to Q^2=1.5 GeV^2 and it is compared to various models:
  - DGLAP (RT, ACOT)
  - Dipole models
  - Mixed between DGLAP and Dipole models
    - Best description of data by DGALP using ACOT, but other phenomenological models describe data well

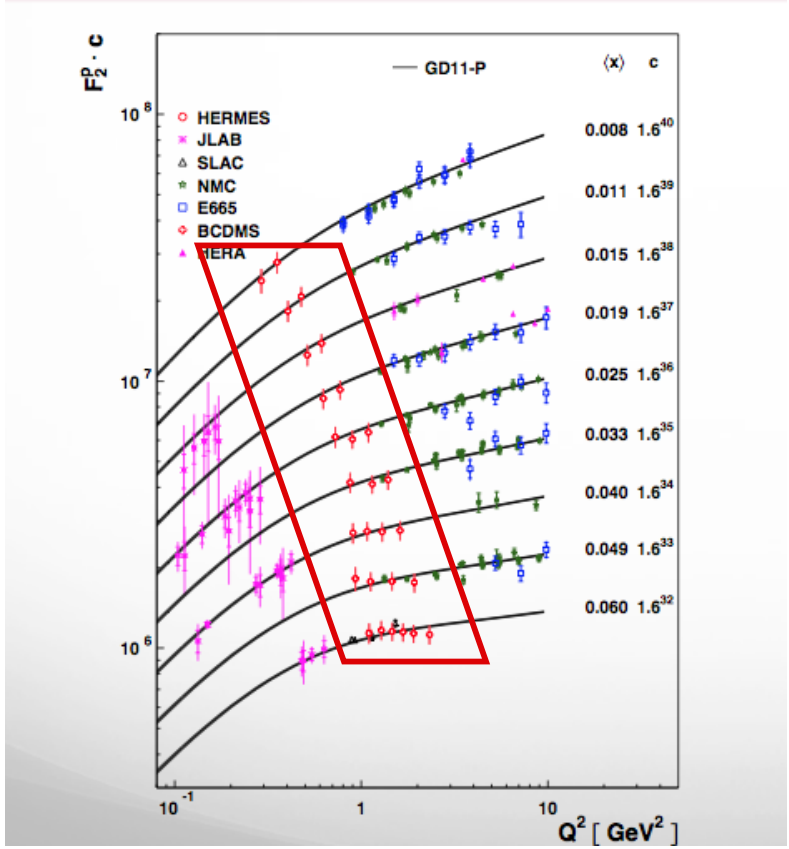
Structure Functions from HERMES

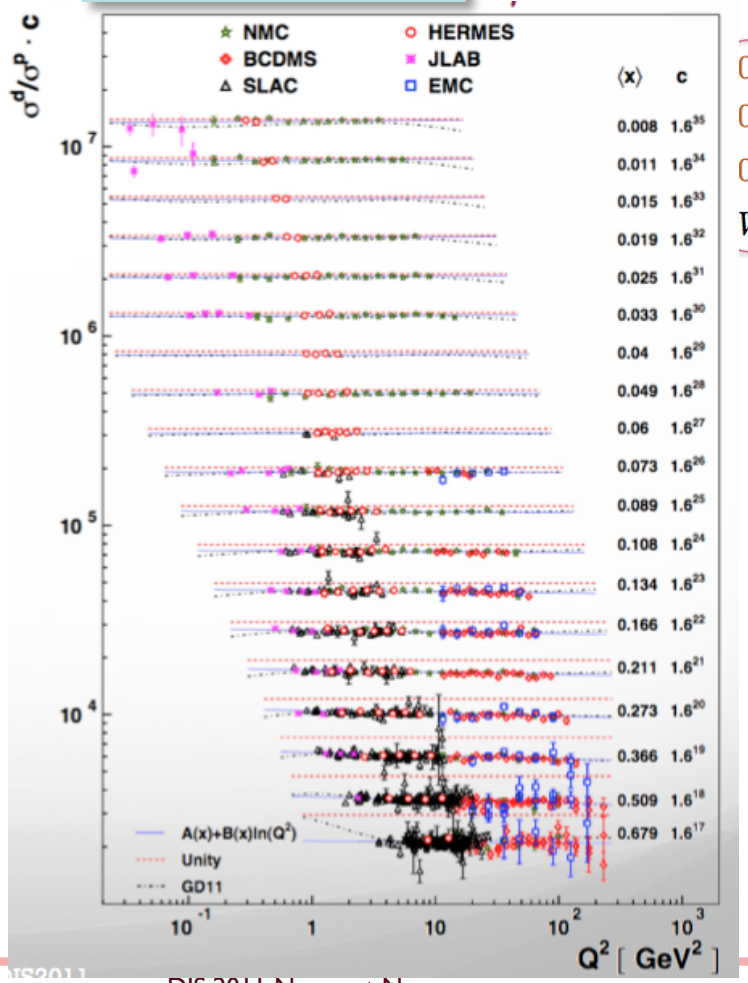


- F2p and F2d Measurements in Gap and Overlap regions
- To reduce systematic uncertainties, proton and deuteron are combined into σ^p/σ^d sensitive to dval/uval

L.de Nardo

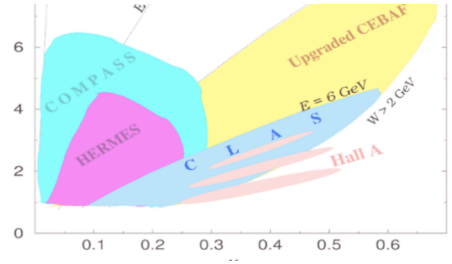
arXiv:1103.5704 (hep-ex) and DESY-11-048
Submitted to JHEP





$0.006 < x < 0.9$
$0.1 < y < 0.85$
$0.2\ \mathrm{GeV}^2 < Q^2 < 20\ \mathrm{GeV}^2$
$W^2 > 5\ \mathrm{GeV}^2$

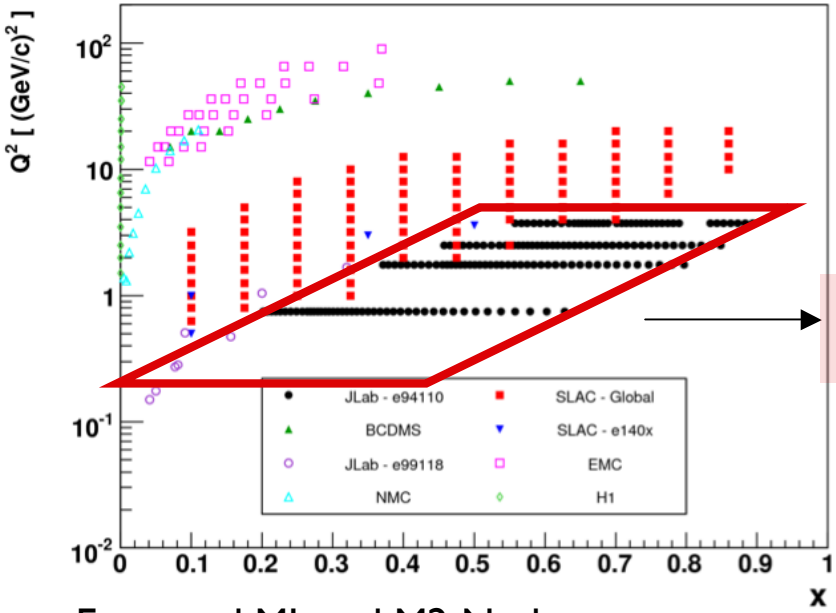
Proton Longitudinal Moments at JLab



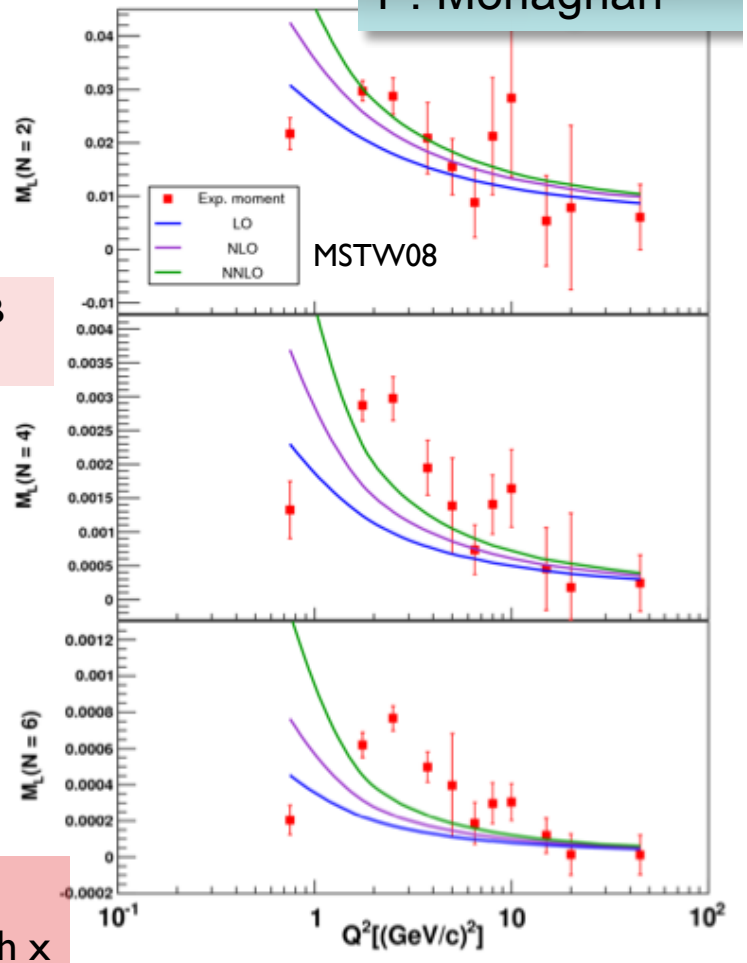
$$\sigma_R = \frac{1}{\Gamma}\frac{d^2\sigma}{d\Omega dE'} = \sigma_T(x,Q^2) + \epsilon\sigma_L(x,Q^2)$$

$\sigma_T \rightarrow F_1$, $\sigma_L \rightarrow F_L$ ➔ Used to extract target mass corrected moments

P. Monaghan



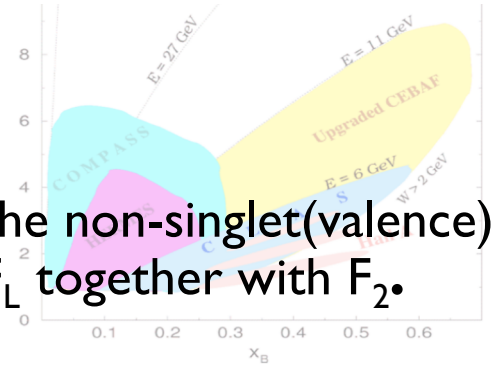
New data from JLAB at high x, low Q^2



- Extracted ML and M2 Nachtmann moments from available proton data of x>0.01 using various models to fill in the gaps of available data
  ➔higher twist effects not subtracted

Large errors indicate that more experimental data is needed
➔ JLab @ 12 GeV with higher precision data at moderate to high x

Non-Singlet Moments at Jlab



- Measuring proton and deuteron moments allows to study the non-singlet(valence) distributions and singlet (sea+gluon) distributions through F_L together with F_2.

- Non-Singlet Moments are extracted from 2p-d data:
  - Large nuclear correction for deuteron data(25%) - no free neutron target
  - Data provide direct confrontation of recent lattice QCD calculations at 4 GeV^2

Preliminary Non-Singlet Moments of the Structure Functions

I. Albayrak

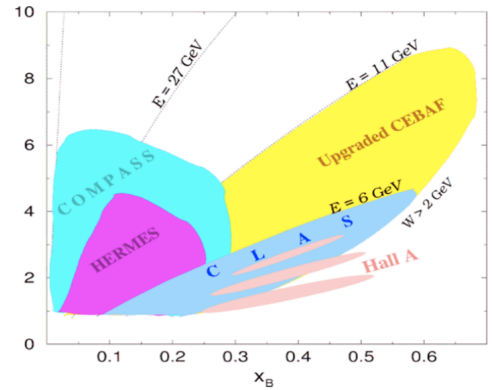
Q^2 (GeV^2)	n	M_2	M_L
2	2	0.044514 (0.00232)	0.00618 (0.005)
	4	0.00782 (0.00130)	0.00235 (0.0005)
3	2	0.04821 (0.00160)	0.00399 (0.00736)
	4	0.00883 (0.00068)	0.00225 (0.00058)
4	2	0.04475 (0.00269)	0.00186 (0.00762)
	4	0.00882 (0.00023)	0.000799 (0.00102)

New Measurements

n	Hall C	Hall B	LQCD1	LQCD2	LQCD3
2	0.049 (17)	0.050 (9)	0.059 (8)	0.091 (8)	0.082 (3)
4	0.015 (3)	0.0094 (16)	0.009 (3)	0.030 (16)	0.023 (7)

?

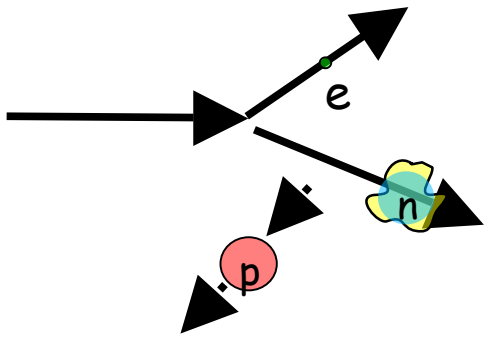
F2n in a model independent approach



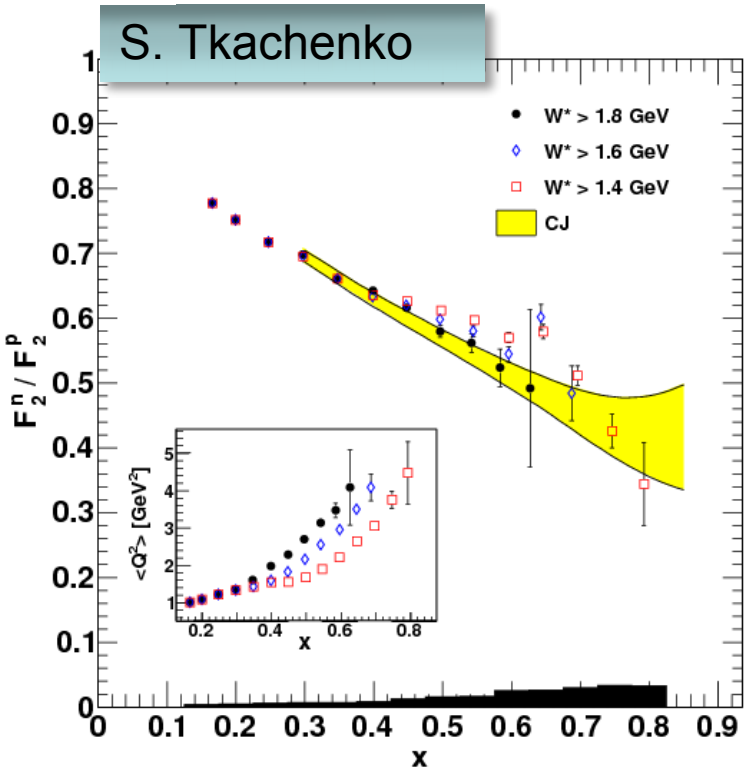
- At JLAB, the d/u ratio is determined from:

$$\frac{F_{2n}}{F_{2p}} \approx \frac{1+4d/u}{4+d/u} \Rightarrow \frac{d}{u} \approx \frac{4F_{2n}/F_{2p}-1}{4-F_{2n}/F_{2p}}$$

- BONUS experiment at JLAB extracts F2n in a model independent way using tagging spectator proton approach:

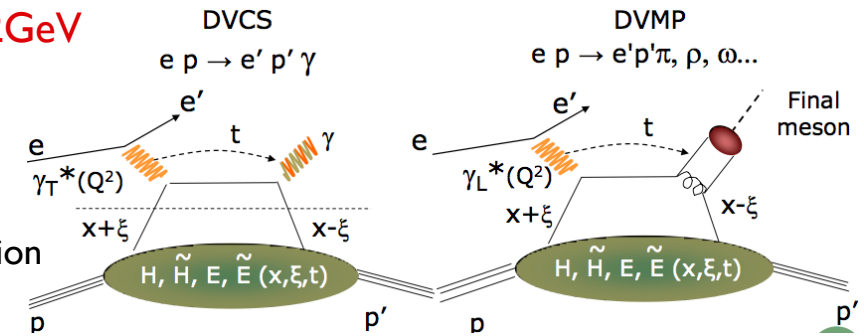


  - detect a low momentum, backward moving proton to emulate a quasi-free neutron target



Generalised Parton Distributions

- JLAB has an intense program on polarised and unpolarised structure functions and more is to come with JLAB@12GeV
- GPDs are correlated quark momentum and helicity distributions in transverse space
  - Cleanest way via Deeply Virtual Compton Scattering
  - Flavour decomposition via Deeply Virtual Meson Production

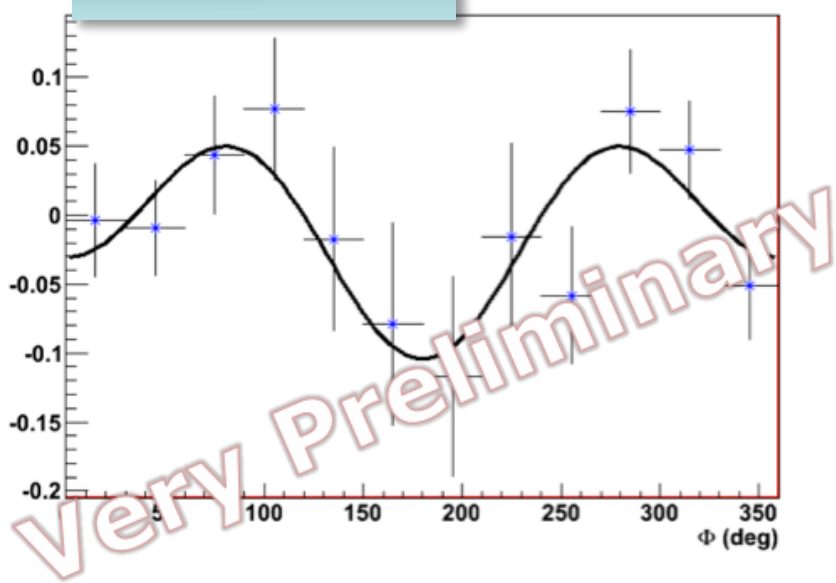


- Highlights of CLAS measurements on GPDs:

DVCS:

- **e1-dvcs** experiment: polarized beam, unpolarized target
  - Beam Spin Asymmetry
- **eg1-dvcs** experiment: polarized beam, polarized target
  - Target Spin Asymmetry
  - Double Spin Asymmetry →

S. Pisano



DVMP:

- **e1-6** experiment: e p → e p ρ^0
  - cross section
  - interpretations
- Other DVMP channels

Final Remarks and Perspectives

(thank you Jeff for a great perspective!)

- Abundant new measurements to provide important constraints on PDFs from different processes:
  - ep, pp, fixed target
  - First time at a DIS workshop we have precision measurements from the LHC providing a lever arm to further constrain PDFs
  - New ideas to address issues related to higher twist, nuclear corrections are confronted with more and more precise measurements from JLAB.
- Hope to combine efforts to complete the picture of the nucleon structure!

Thanks to the organisers
And
To all the speakers!