News from HERA and data in HERPDF0.2 set

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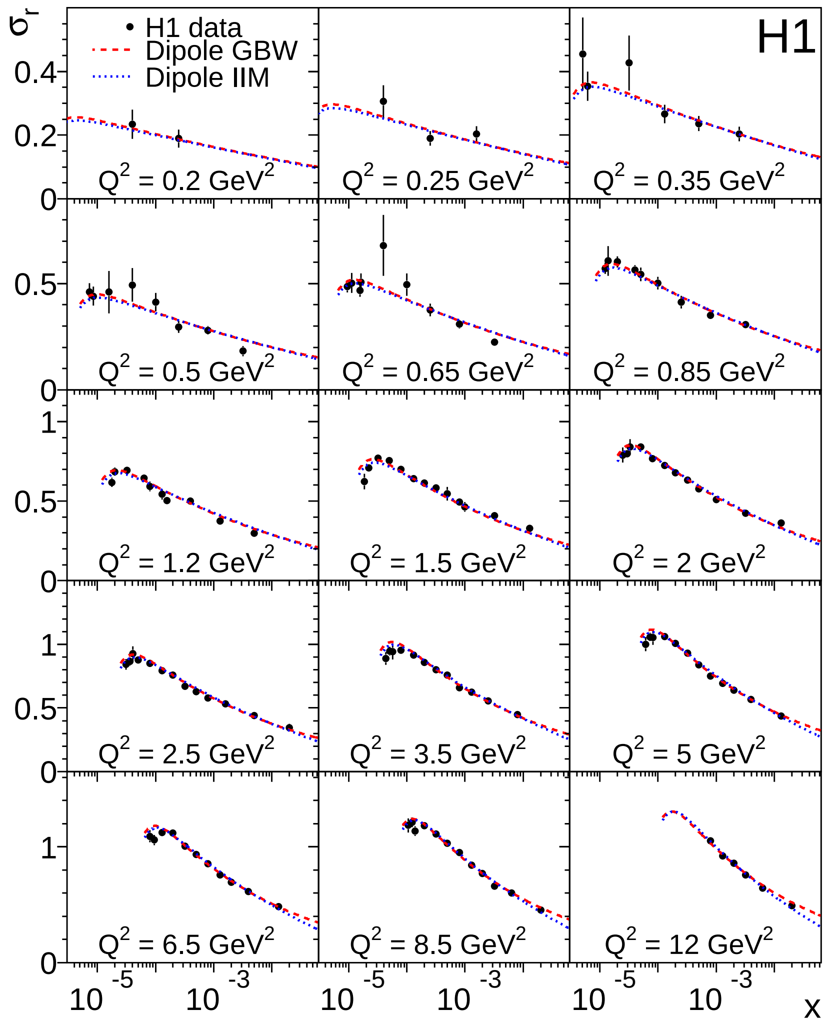
Data included in HERAPDF0.2 set

Data Set		x range		Q^2 range GeV^2		$\mathcal{L}$ pb^{-1}	Mode	$\sqrt{s}$ GeV	ref.
H1 svx-min. bias	95-00	5×10^{-6}	0.02	0.2	12	2.1	e^+p	301-319	[1]
H1 low Q^2	96-00	2×10^{-4}	0.1	12	150	22	e^+p	301-319	[2]
H1 NC	94-97	0.0032	0.65	150	30000	35.6	e^+p	301	[3]
H1 CC	94-97	0.013	0.40	300	15000	35.6	e^+p	301	[3]
H1 NC	98-99	0.0032	0.65	150	30000	16.4	e^-p	319	[4]
H1 CC	98-99	0.013	0.40	300	15000	16.4	e^-p	319	[4]
H1 NC	99-00	0.00131	0.65	1?0	30000	65.2	e^+p	319	[5]
H1 CC	99-00	0.013	0.40	300	15000	65.2	e^+p	319	[5]
ZEUS BPC	95	2×10^{-6}	6×10^{-5}	0.11	0.65	1.65	e^+p	301	[6]
ZEUS BPT	97	6×10^{-7}	0.001	0.045	0.65	3.9	e^+p	301	[7]
ZEUS SVX	95	1.2×10^{-5}	0.0019	0.6	17	0.2	e^+p	301	[8]
ZEUS NC	96-97	6×10^{-5}	0.65	2.7	30000	30.0	e^+p	301	[9]
ZEUS CC	94-97	0.015	0.42	280	17000	47.7	e^+p	301	[10]
ZEUS NC	98-99	0.005	0.65	200	30000	15.9	e^+p	319	[11]
ZEUS CC	98-99	0.015	0.42	280	30000	16.4	e^+p	319	[12]
ZEUS NC	99-00	0.005	0.65	200	30000	63.2	e^+p	319	[13]
ZEUS CC	99-00	0.008	0.42	280	17000	60.9	e^+p	319	[14]

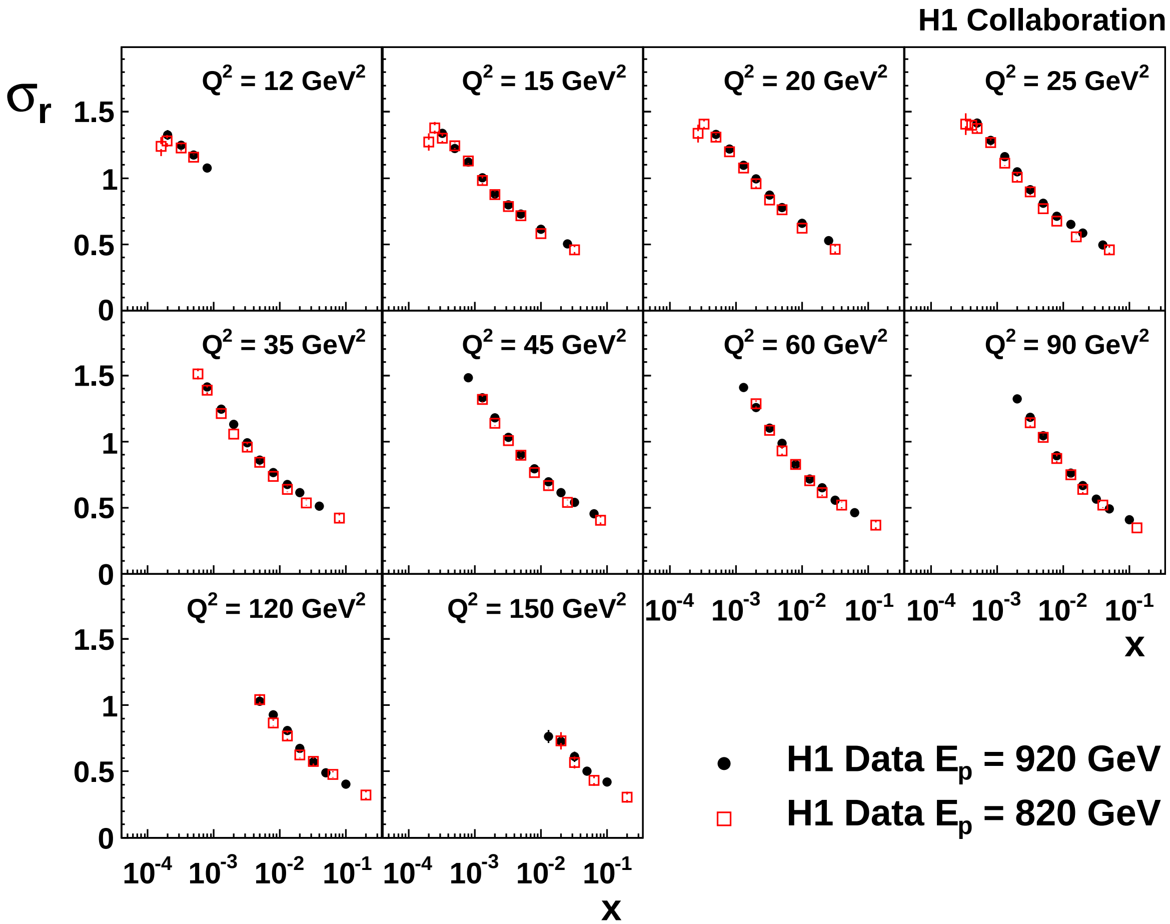
All the datasets included in combined H1-ZEUS set. Blue are new data vs previous average.

Low $0.2 \leq Q^2 \leq 12$ GeV^2 H1 data



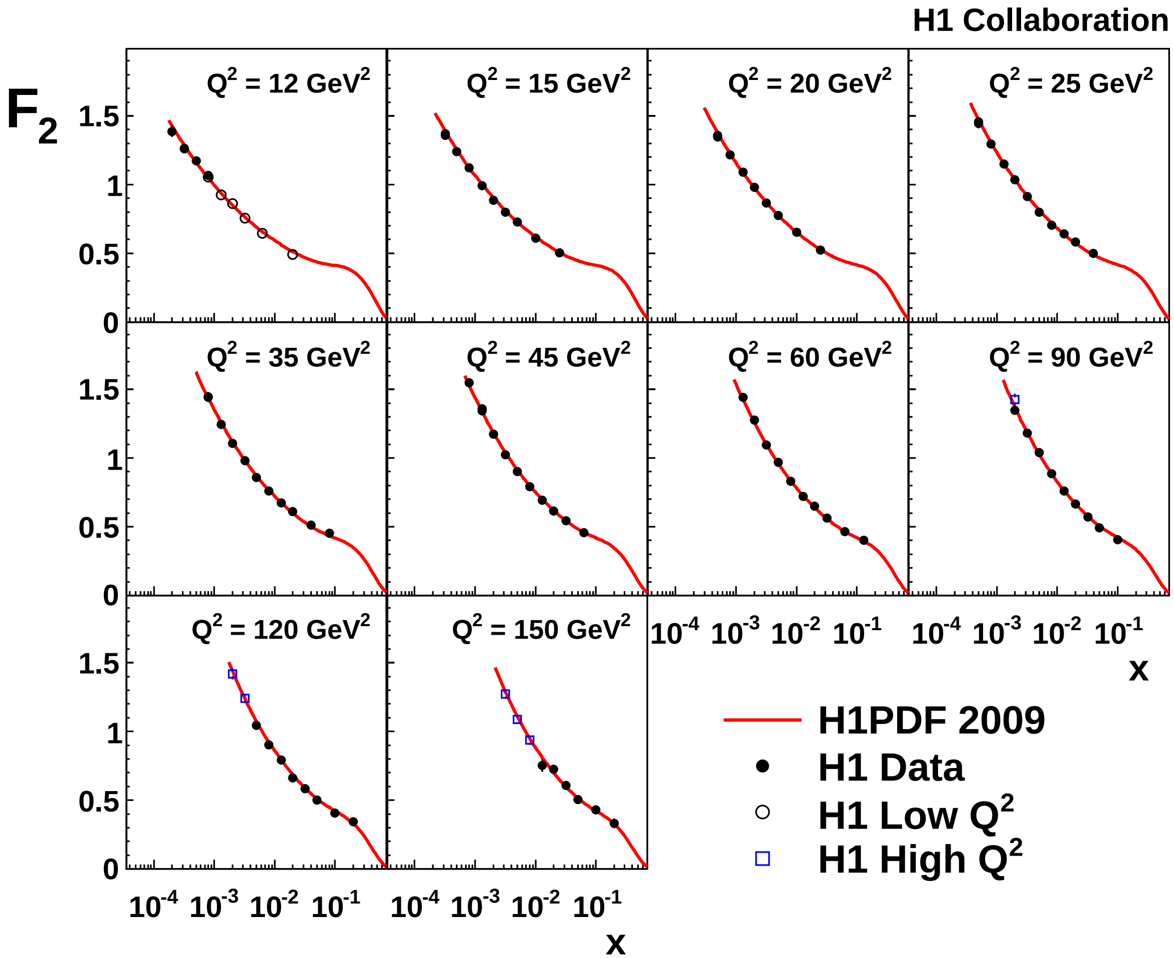
- Combined H1 data from years 1995-2000, $E_p = 820$ and $E_p = 920$ GeV using special “minimum bias” runs including runs with “shifted” vertex position.
- Typically 2% precision for $Q^2 \geq 2$ GeV^2.
- Submitted for publication (arXiv:0904.0929).
- Extends to high $y = 0.8$.
- Can be described by Dipole Models, from $Q^2 \geq 3.5$ GeV^2 included in QCD fits.

Medium $12 \le Q^2 \le 150$ GeV^2 H1 data



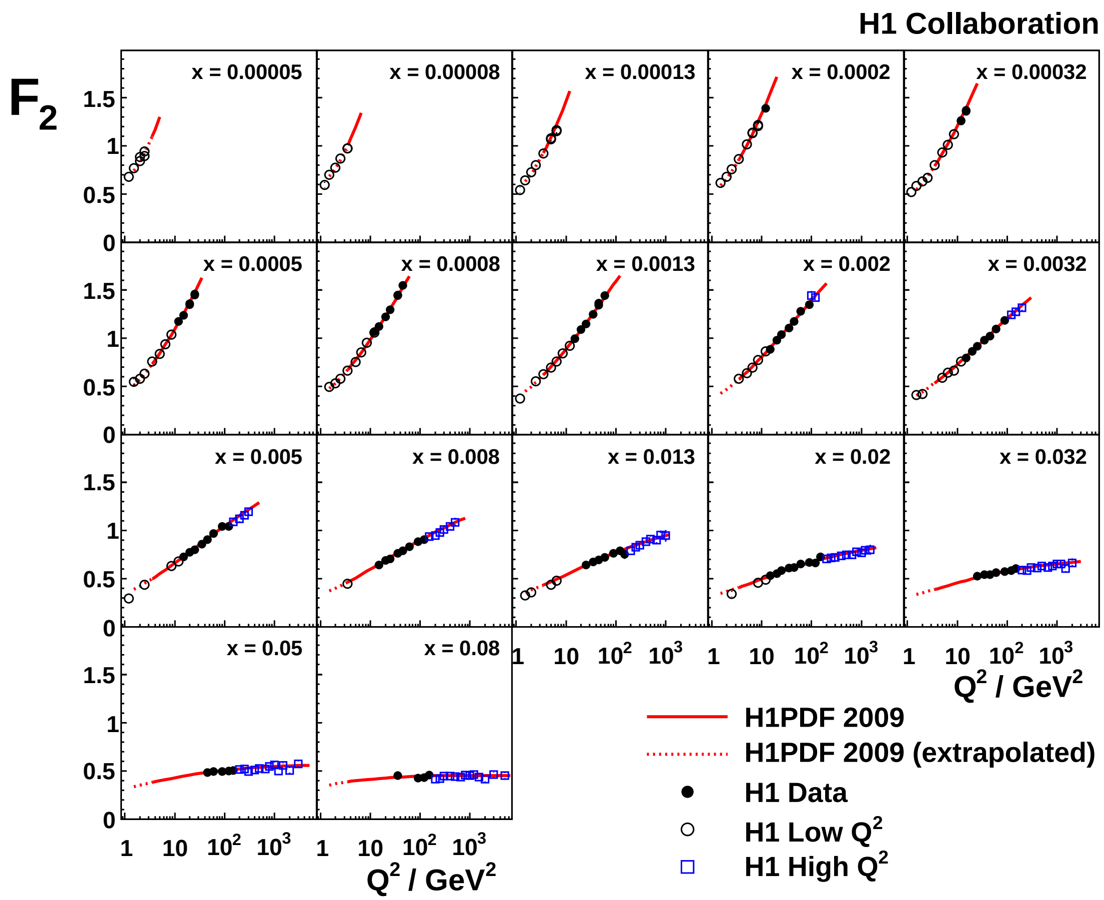
- New analysis of 2000 ($E_p = 920$ GeV) compared to corrected (up to 2.5%) 1996/97 data ($E_p = 820$).
- Agree well, combine. Results are available as *arXiv:0904.3513*.

Medium $12 \leq Q^2 \leq 150$ GeV^2 H1 data



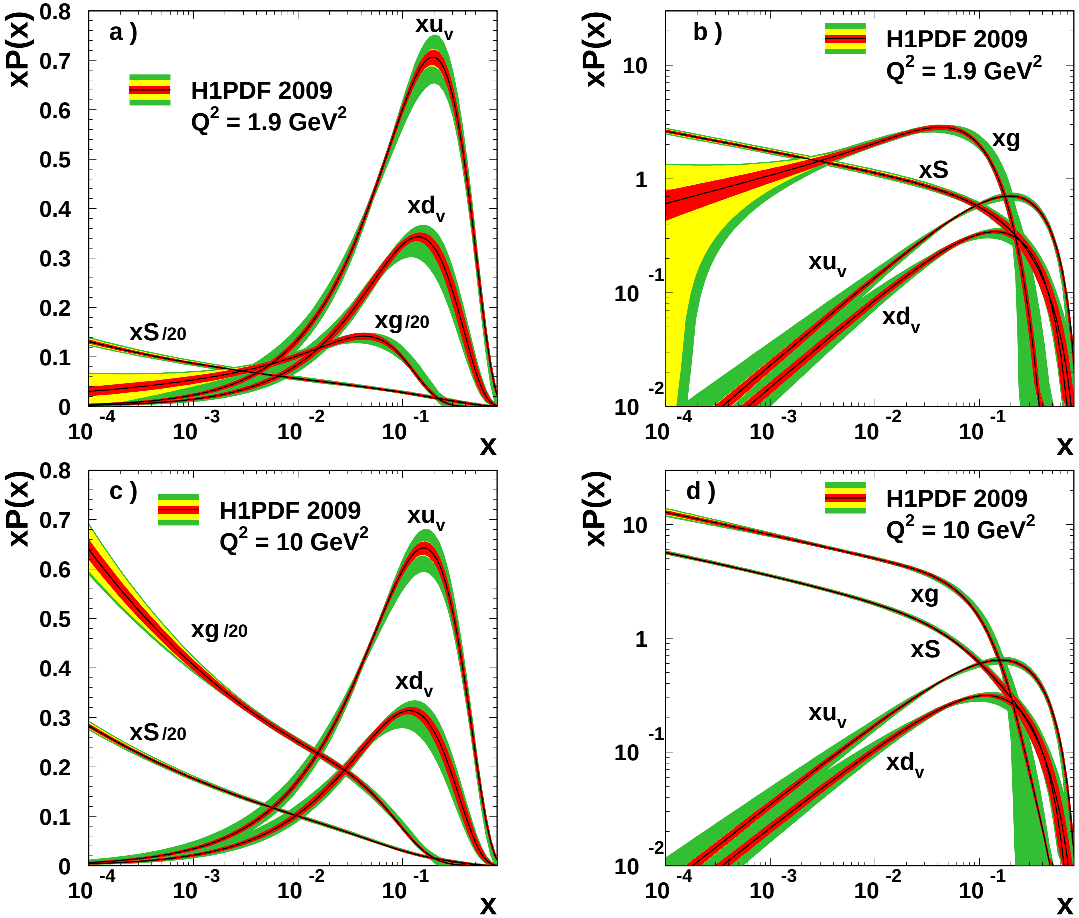
- Up to 1.3% precision for $Q^2 \sim 20$ GeV^2.
- Described well by NLO QCD fit.

H1 data vs x



- Low, medium and high Q^2 data collected in 1994-2000 (HERA-I).
- All H1 data used for NLO QCD fit (H1PDF2009).

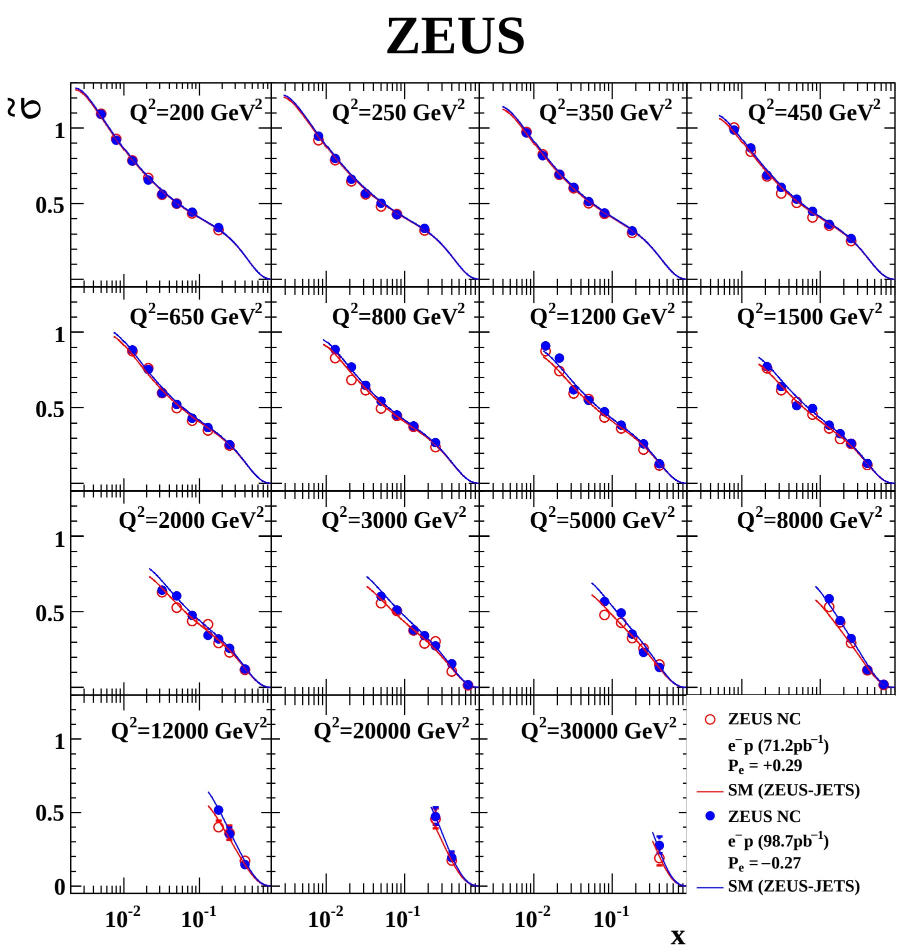
H1PDF2009 set



- Fit using inclusive DIS cross section data from H1 only.
- Improved theoretical treatment of heavy quarks (TR-scheme)
- Similar to HERAPDF0.2 fit.

Separation of **experimental**, **model** and parameterization uncertainty.
Parameterization uncertainty dominates at high *x*.

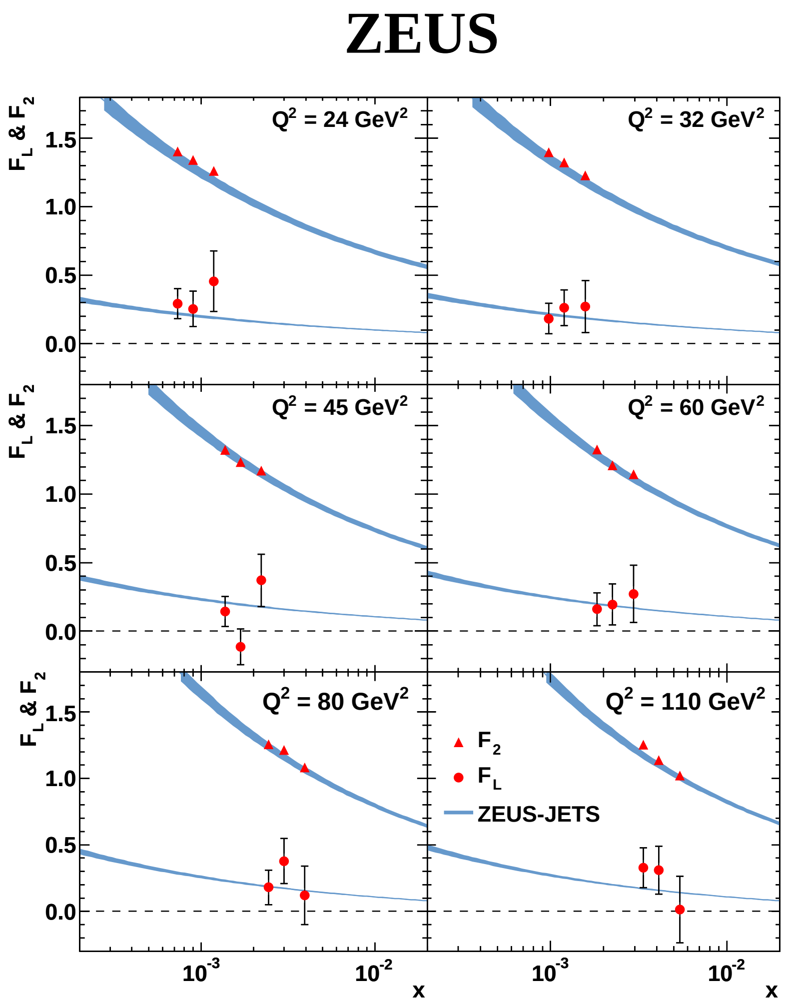
Measurements at HERA II – $e^- p$ data from ZEUS



- Analysis of all HERA-II $e^- p$ data collected in 2005 – 2006 (DESY-08-202)
- Integrated luminosity of 169.9 pb^{-1}.
- Data taken with longitudinally polarized e^- beam.
- Included in ZEUS PDF fits.

Not included in HERAPDF 0.2 set — will be combined together including all HERA-II data.

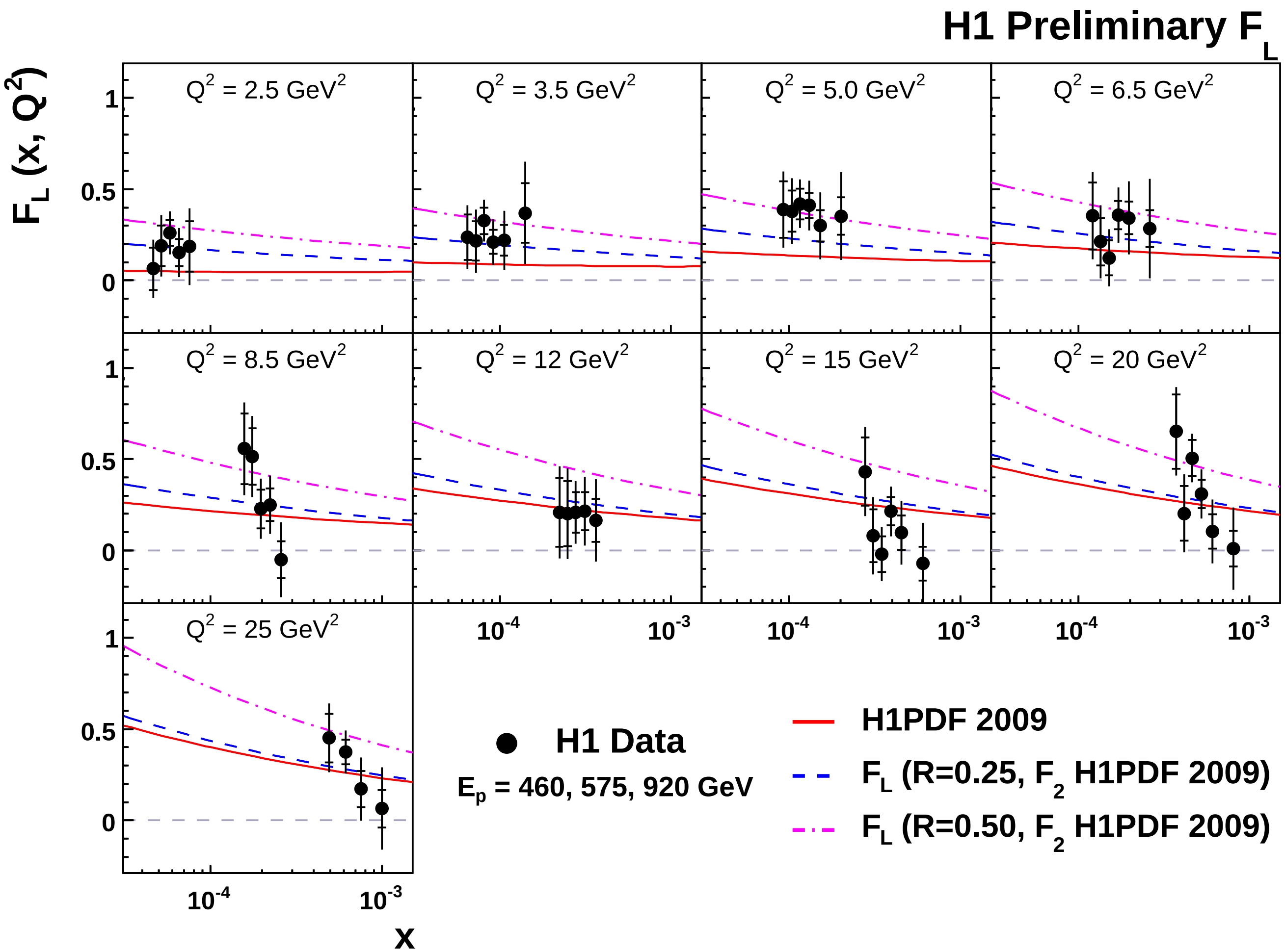
Measurement of F_L by ZEUS



- Measurement based on HERA runs with reduced $E_p = 460$ GeV and $E_p = 575$ GeV (DESY-09-046).
- Extraction of both F_L and F_2 s.f. (previously F_2 was extracted using assumptions on F_L leading to some model dependence for higher $y > 0.35$ data.)
- Measurement of $R = F_L/(F_2 - F_L) = 0.18^{+0.07}_{-0.05}$

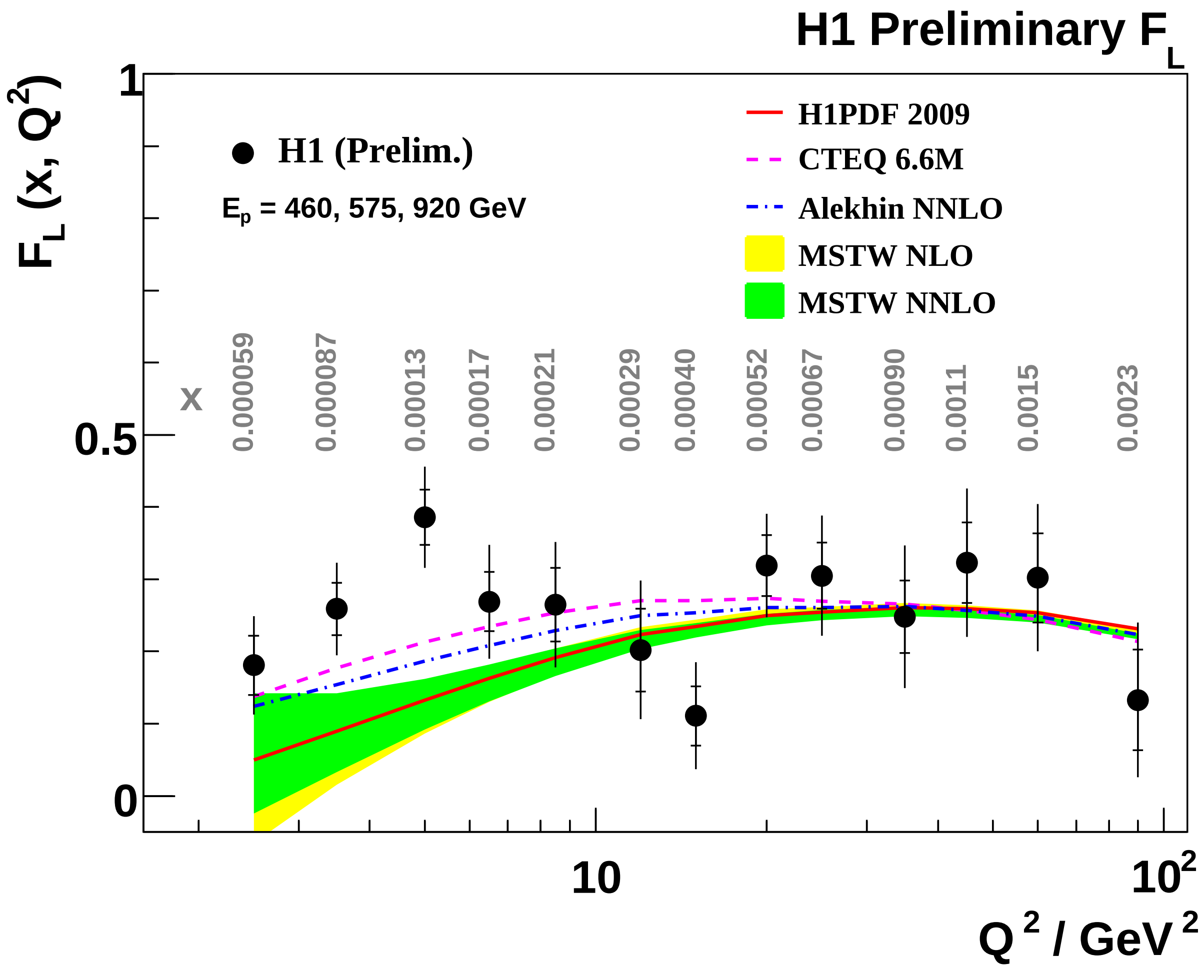
Not included in HERAPDF 0.2 set — work in progress how to combine low E_p / F_L data.

F_L vs x, Q^2



Preliminary measurement of H1 extending down to 2.5 GeV^2 using Backward Silicon Tracker

F_L measured at $Q^2 < 100$ GeV^2



MSTW and H1PDF 2009 predictions use the same scheme to calculate F_L.
Data agree better with calculation of CTEQ.

Combination Procedure

- All NC,CC $e^{\pm}p$ data are combined in one step. This allows for coherent propagation of the systematic uncertainties.
- Before the combination, the data are corrected to a common x, Q^2 grid using parameterizations of NC,CC cross section. QCD fit is used for $Q^2 \geq 4$ GeV^2 and fractal model fit for $Q^2 < 4$ GeV^2 data.
- The data collected at $E_p = 820$ GeV are corrected to $E_p = 920$ GeV for all point excluding $y > 0.35$ NC data. The model uncertainty arising from this CME correction is negligible compared to experimental errors.
- The correlated systematic uncertainties are considered uncorrelated between H1 and ZEUS. To study importance of this approximation, similar sources were identified and assumed to be correlated. Additional **procedural** uncertainties are introduced for possible correlation of photoproduction background and hadronic final state simulation.

Combination χ^2

$$\chi^2_{\rm exp}(\boldsymbol{m},\boldsymbol{b}) = \sum_i \frac{\left[m^i - \sum_j \gamma^i_j m^i b_j - \mu^i\right]^2}{\delta^2_{i,\rm stat}\left(m^i - \sum_j \gamma^i_j m^i b_j\right) + \left(\delta_{i,\rm uncor}\, m^i\right)^2} + \sum_j b_j^2 .$$

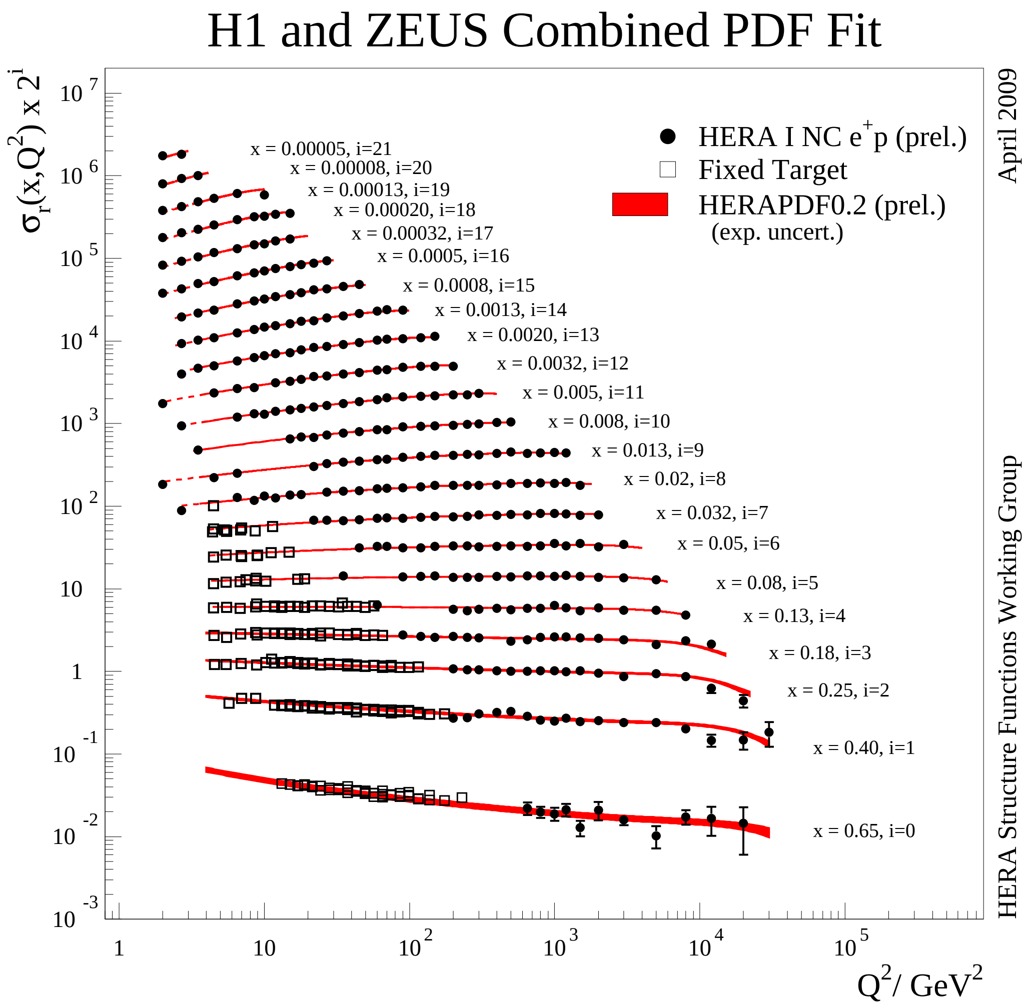
- μ^i — measured central value at point i
- γ^i_j, $\delta_{i,\rm stat}$, $\delta_{i,\rm uncor}$ — relative correlated systematic, statistical and uncorrelated systematic uncertainty.

The function $\chi^2_{\rm exp}$ depends on the set of underlying physical quantities m^i (vector $\boldsymbol{m}$) and the set of systematic uncertainties b_j ($\boldsymbol{b}$).

All(normalization, correlated, uncorrelated) systematic uncertainties are assumed to be **multiplicative** and statistical errors are rescaled based on estimated (instead of measured) number of events.
Extra procedural error for if only normalizations are considered multiplicative.

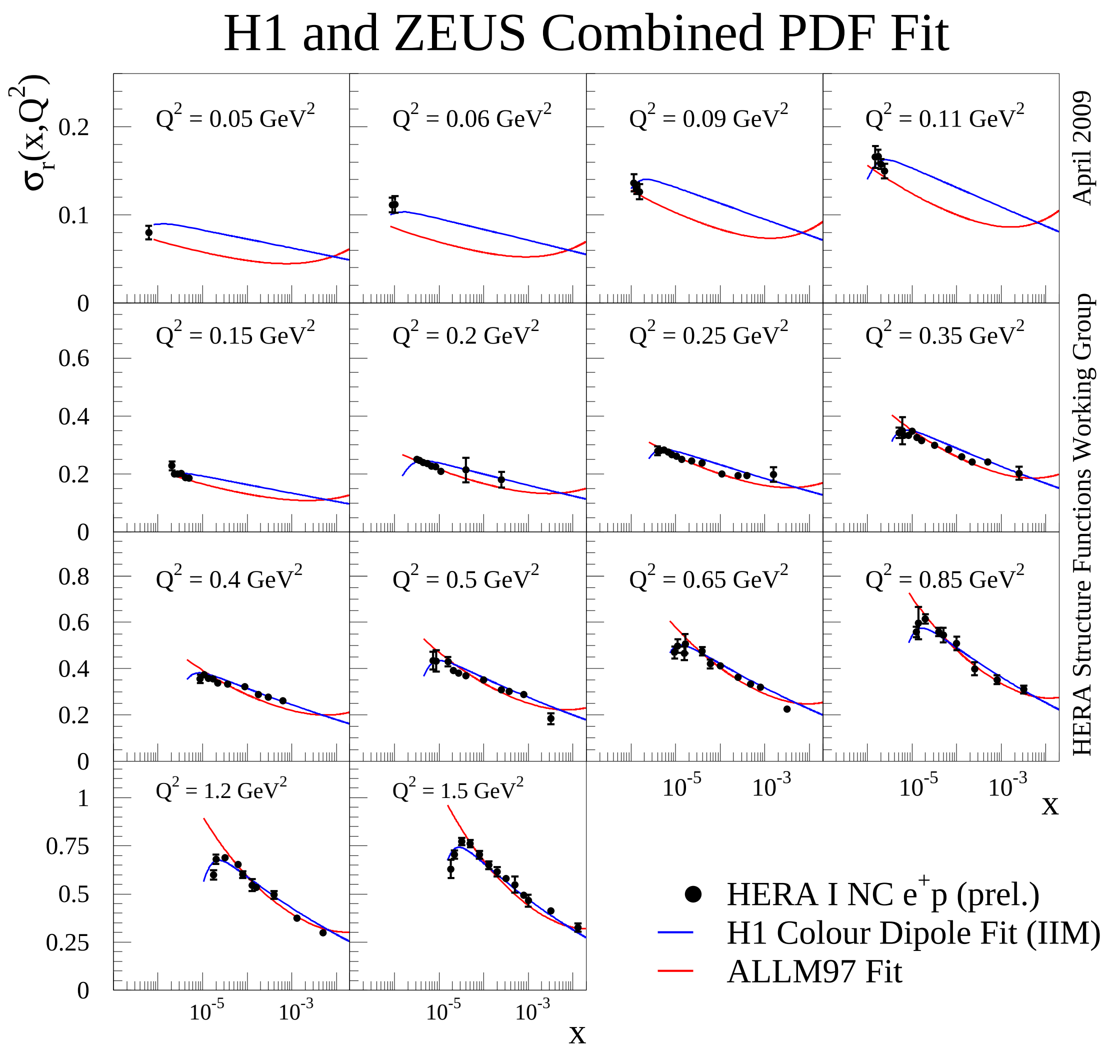
Alternative: average/fit $\boldsymbol{\log\sigma_r}$, in this case all uncertainties should be treated as additive (also normalizations). Consistent resulting average.

Combination Results



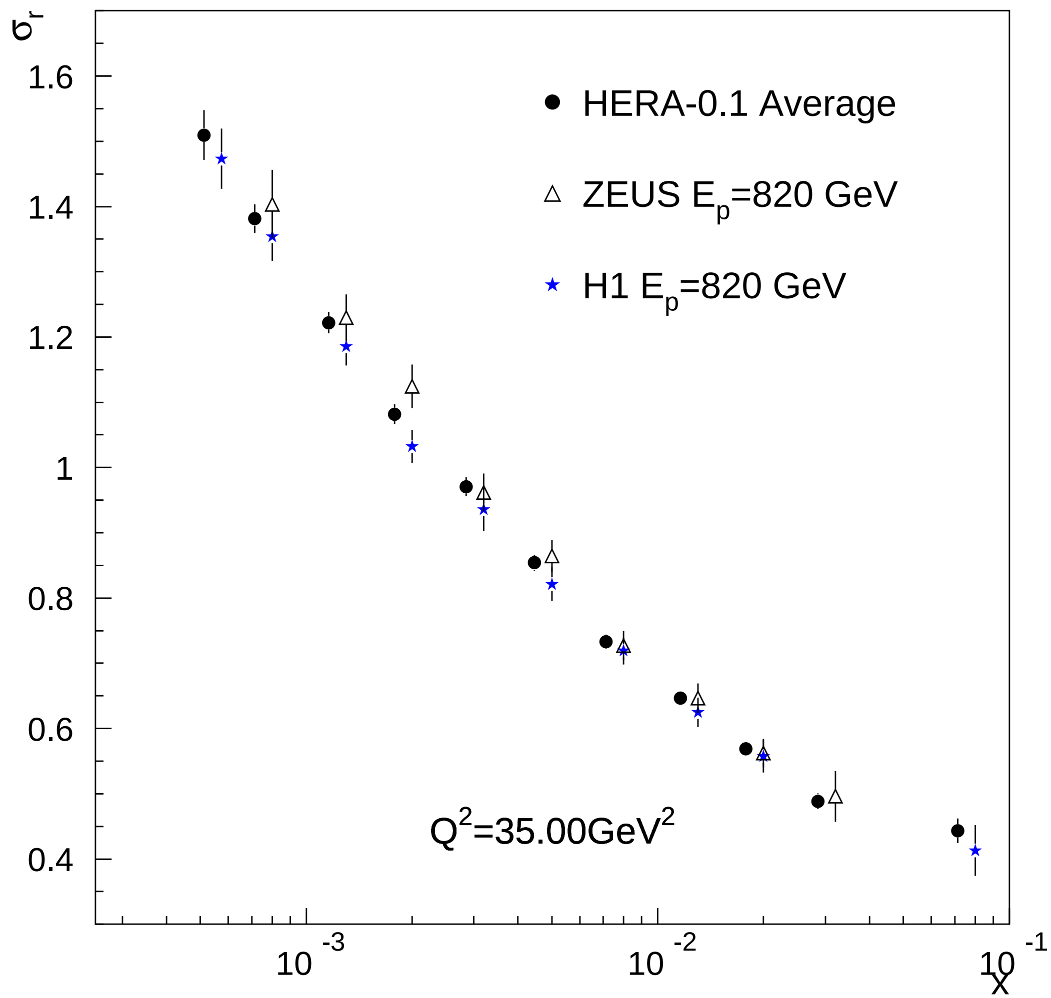
- Average 1397 input data points to 741 cross section measurements.
- 110 separate correlated error sources.
- Good consistency, $\chi^2/n_{\mathrm{dof}} = 641/656$, no tension seen from distribution of pulls for all kinematic domains.
- Data precision reaches $\sim$ 1% for $Q^2 \sim 20$ GeV^2 NC e^+p sample.

NC e^+p HERA for low Q^2



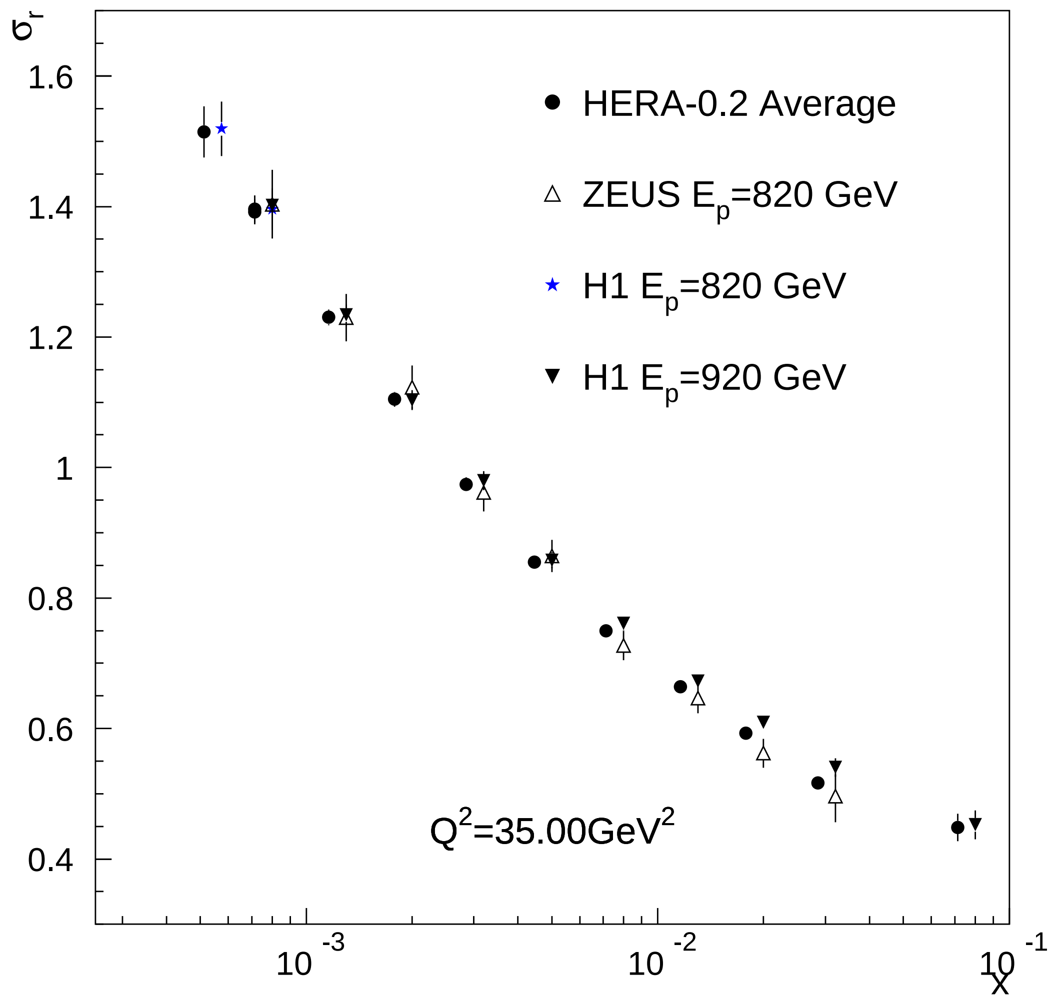
- Compared to data in `HERAPDF 0.1` set, extension to low Q^2 using ZEUS BPT, BPC and SVX as well as H1 data.
- The data are compared to ALLM97 parameterization and Iancu, Itakura and Munier (IIM) dipole model fit to low Q^2 H1 data.

Changes for $Q^2 \sim 30$ GeV^2 range



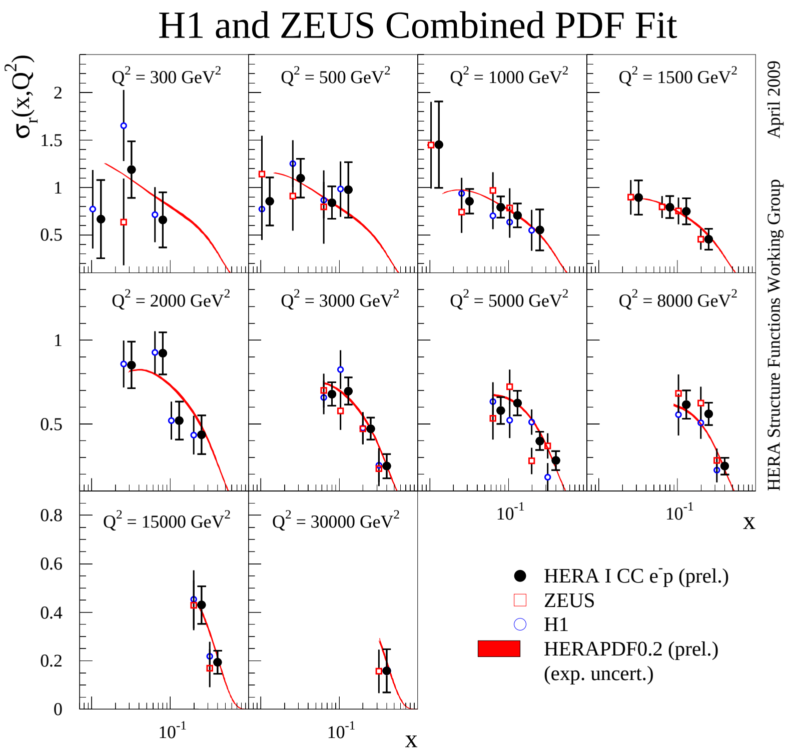
Before the addition of the latest H1 data (HERAPDF 0.1) ...

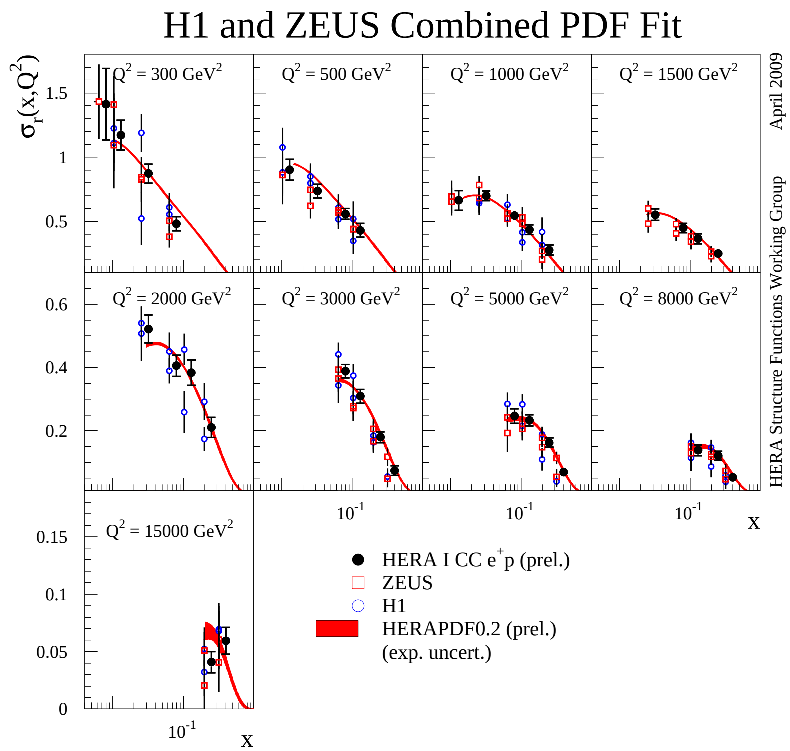
Changes for $Q^2 \sim 30$ GeV^2 range



All HERA-I data. Precision improves from $\sim$ 1.50% to $\sim$ 1.05% (new H1 data: 1.45%)

CC $e^{\pm}p$ data





- CC data allows flavor separation using HERA data only.
- Average improves precision of the data but ultimate precision will come with the combination of the complete HERA dataset.

Summary

- Plenty of new data from HERA.
- HERA combined cross section data include new H1 results for $0.2 \leq Q^2 \leq 150$ GeV^2 and ZEUS data for $0.045 \leq Q^2 \leq 0.65$ GeV^2, significantly improve precision for $Q^2 \leq 150$ GeV^2.

All the data intended for the HERA-I publication are released/included in the combination.