H1 QCD Fits

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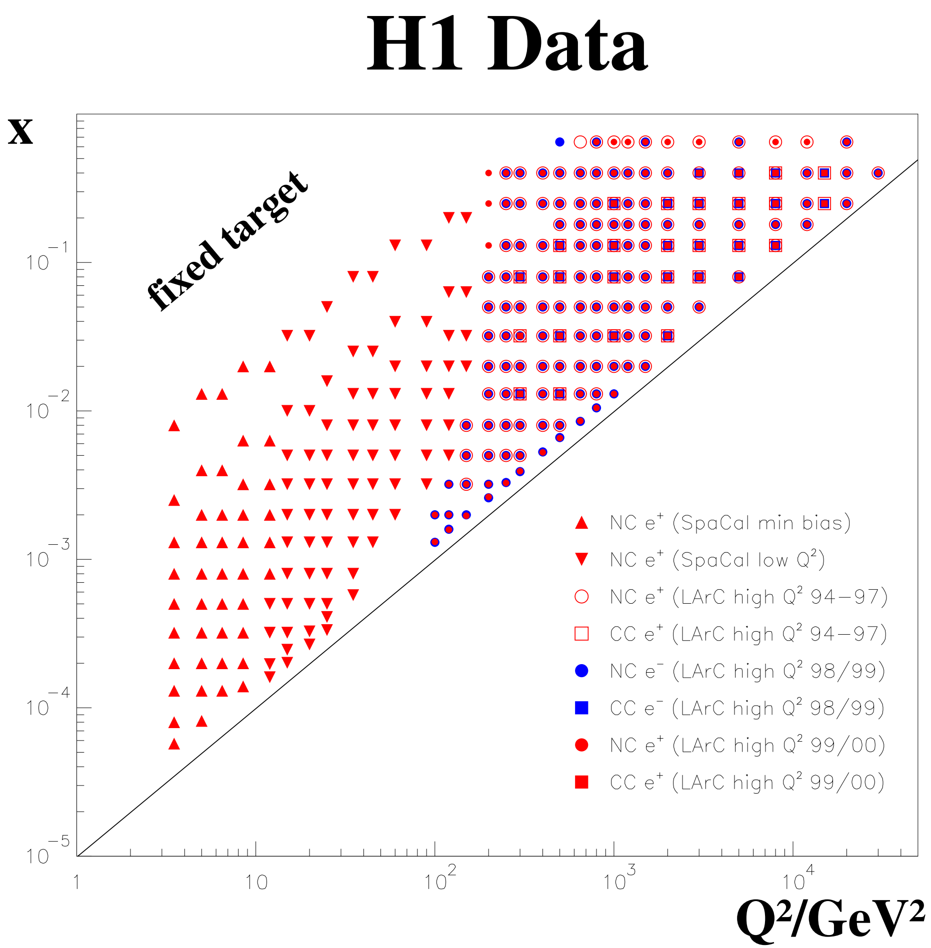
Idea of QCD Fitting in H1:

Focus on H1 data

"What do we learn from our data?"
"What problems do we face?"

- H1 inclusive data
- Complementary Approaches of H1 Fits
- Uncertainty bands

H1 Inclusive Data Sets



Data used in published H1 fits:

– Low Q^2 NC e^+p (96-97)
  $1.5 < Q^2 < 150$ GeV^2
– High Q^2 e^+p (94-97)
  NC: $150 < Q^2 < 30000$ GeV^2
  CC: $300 < Q^2 < 15000$ GeV^2

New H1 Datasets:

- NC at $150 < Q^2 < 30000$ GeV^2
  e^-p 98-99 published
  e^+p 99-00 prelim.
  high y, $y = 0.75$, $100 < Q^2 < 800$ GeV^2
  e^-p 98-99 prelim., e^+p 99-00 prelim.
- CC at $300 < Q^2 < 15000$ GeV^2
  e^-p CC 98-99 published
  e^+p CC 99-00 prelim.

Experimental Uncertainties

High quality of the inclusive data requires careful treatment of experimental uncertainties.

Statistical and Systematic Errors

$Q^2 \lesssim 100$ GeV^2 : stat. $\simeq 1\%$, syst. $\lesssim 3\%$

only for $Q^2 \gtrsim 1000$ GeV^2 : stat. $>$ syst. uncertainty

Sources of Correlated Systematic Uncertainties:

E_{el}:	electron energy calibration
θ_{el}:	polar angle of electron
E_{had} :	hadronic energy calibration
Noise:	noise suppression algorithm
BG:	background estimate by Monte Carlo
Vap:	cut against γp background (CC only)
Asy:	background subtraction using wrong charge lepton candidates (NC, high y only)

Correlation between H1 Datasets:

dataset	reaction	E_{el}	θ_{el}	E_{had}	Noise	BG	Vap	Asy
min bias	e^+p NC	E1	T1	H1	N1	B1	–	–
low Q^2	e^+p NC	E1	T1	H1	N1	B1	–	–
high Q^2 94-97	e^+p NC	E2	T2	H2	N1	B2	–	–
high Q^2 94-97	e^+p CC	–	–	H2	N1	B2	V1	–
high Q^2 98/99	e^-p NC	E2	T3	H2	N1	B2	–	A1
high Q^2 98/99	e^-p CC	–	–	H2	N1	B2	V2	–
high Q^2 99/00	e^+p NC	E2	T3	H2	N1	B2	–	A1
high Q^2 99/00	e^+p CC	–	–	H2	N1	B2	V2	–

the same normalisation for NC and CC datasets of the same year

Two Complementary Approaches

H1 "$\alpha_s + g$" Fit

- Simultaneous extraction of
  α_s and gluon
- NC Proton data only
  H1 e^+p NC
  BCDMS μp ($y_\mu > 0.3$)
- Medium Q^2
  $3.5 \text{ GeV}^2 < Q^2 < 3\,000 \text{ GeV}^2$
- Fixed Flavour Scheme
  massive c, b
- "minimized set" of input PDFs
  gluon, "valence like", "sea like"
  $x\,g$, $x\,V$, $x\,A$

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New QCD FIT

- Focus on new H1 high Q^2 data
  α_s fixed
- All inclusive H1 data
  NC & CC, e^+p & e^-p
  BCDMS $p + d$
- Medium and high Q^2
  $3.5 \text{ GeV}^2 < Q^2 < 30\,000 \text{ GeV}^2$
- Massless Parton Scheme
- "standard set" of input PDFs
  $x\,g$, $x\,u_v$, $x\,d_v$, $x\,Sea$
- Flavour decomposition of Sea
  from external sources

Common Ingredients to Both Fits

- MRST type Parameterisation of Parton Distribution Functions
  $xpdf(x) = ax^b(1-x)^c(1+d\sqrt{x}+ex+\dots)$
  reduce number of parameters by constraints on
  momentum sum rule and quark counting rules
  investigate parameter space for parametric forms

- Full treatment of experimental errors
  in an extended covariance approach

- Variation of model parameters
  (α_s, charm mass, bottom mass, Q^2_{min}, ...)

Definition of χ^2

- Normalisation and systematic uncertainties are treated in the fit.
- We explicitly allow the data points to be shifted by the fit

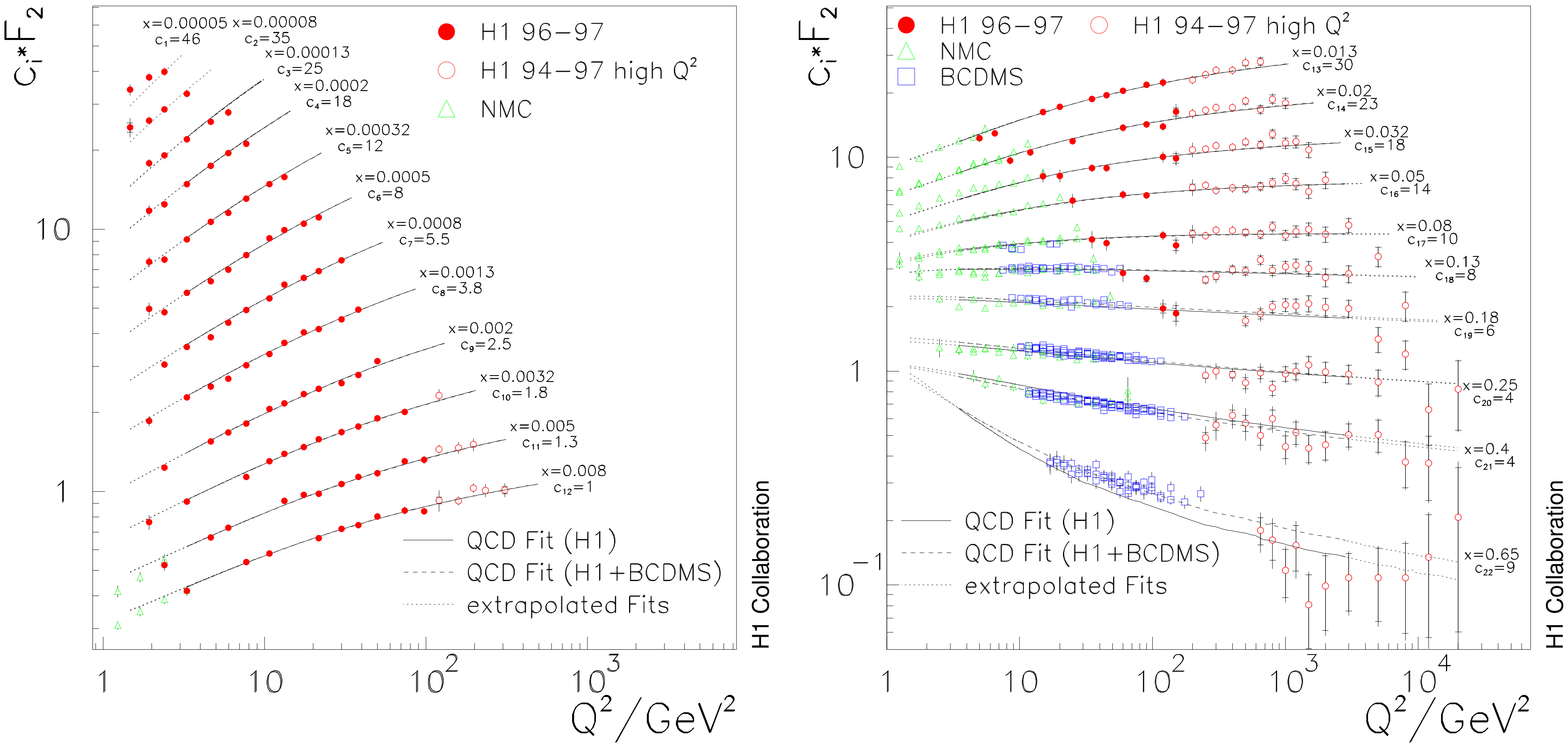
$$\chi^2 = \sum_k^{n_{exp}} \sum_i^{N_k} \frac{\left(\sigma_{k,i}^{exp} - \sigma_{k,i}^{th} \cdot (1 - n_k \delta_k^{norm} - \sum_j^{n_s(k)} s_{k,j}\, \delta_{k,i,j}^{syst})\right)^2}{\delta_{k,i}^{sta\,2} + \delta_{k,i}^{unc\,2}}$$

$$+ \sum_k^{n_{exp}} n_k^2 + \sum_k^{n_{exp}} \sum_j^{n_{s(k)}} s_{j,k}^2$$

$\sigma_{k,i}^{exp}$:	measurement i of dataset k	$\delta_{k,i}^{sta}$:	statistical error
$\sigma_{k,i}^{th}$:	prediction for data point i of dataset k	$\delta_{k,i}^{unc}$:	uncorrelated systematic error
n_{exp}:	number of datasets	$\delta_{k,i,j}^{sys}$:	correlated systematic error of source j
N_k:	number of data points in dataset k	δ_k^{norm}:	uncertainty of dataset normalisation
		n_k:	shift of normalisation
		$s_{k,j}$:	shift of systematic of source j

"Pascaud and Zomer" method, extended χ^2 (preprint LAL-95-05):

H1 "$\alpha_s + g$" Fit: Structure Function F_2

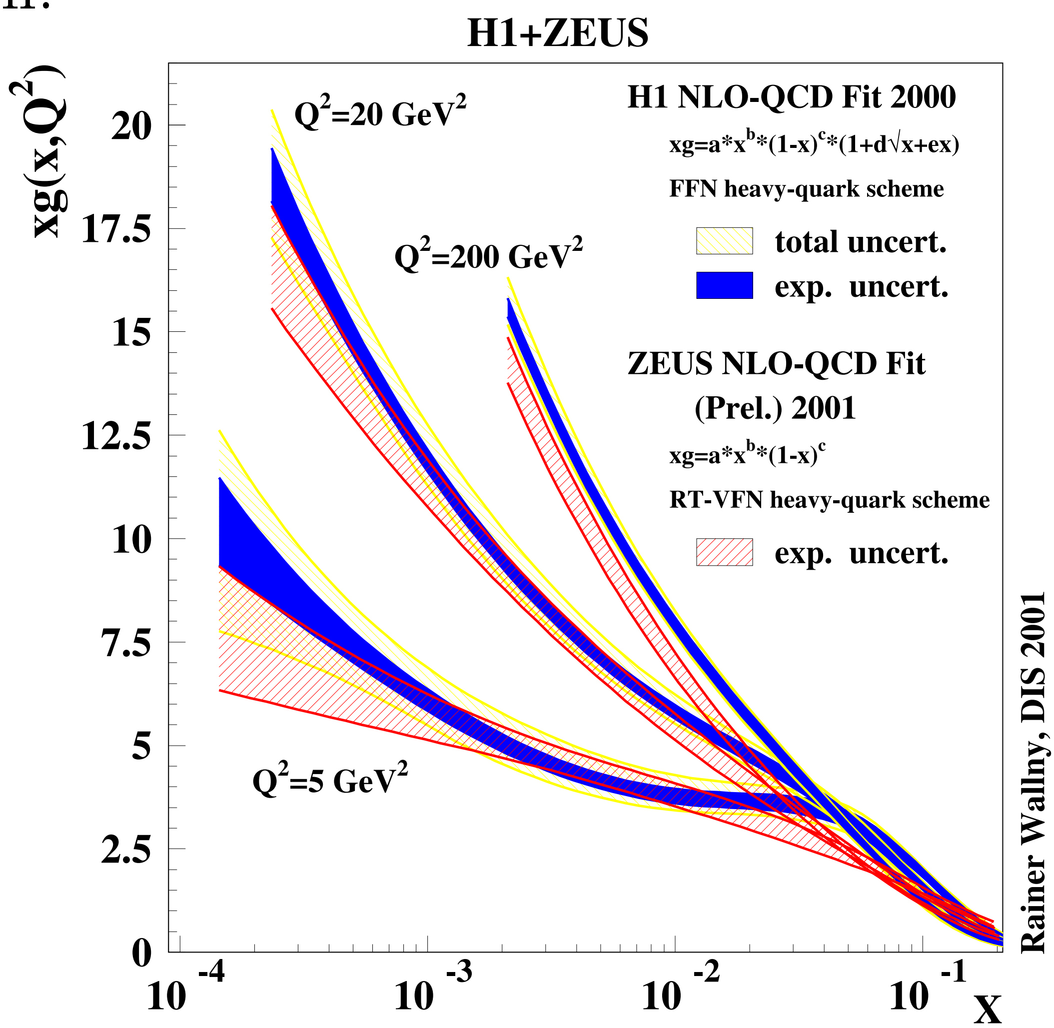


scaling violations well described by the NLO QCD fit

Results from H1 "$\alpha_s + g$" Fit

$$\alpha_s(M_Z^2) = 0.115 \pm 0.0017(\text{exp})^{+0.0009}_{-0.0005}(\text{model})$$
$$\pm 0.005 \text{ renorm./fac. scale unc.}$$

Gluon:



H1: $xg = ax^b(1-x)^c(1 + d\sqrt{x} + ex)$

ZEUS : $xg = ax^b(1-x)^c$

Variation of Parametric Forms (Envelope)

Perform investigation of parameter space (similar to CTEQ6) for general forms of MRST type:
$x\,PDF = ax^b(1-x)^c(1+d\,\sqrt{x}+e\,x)$

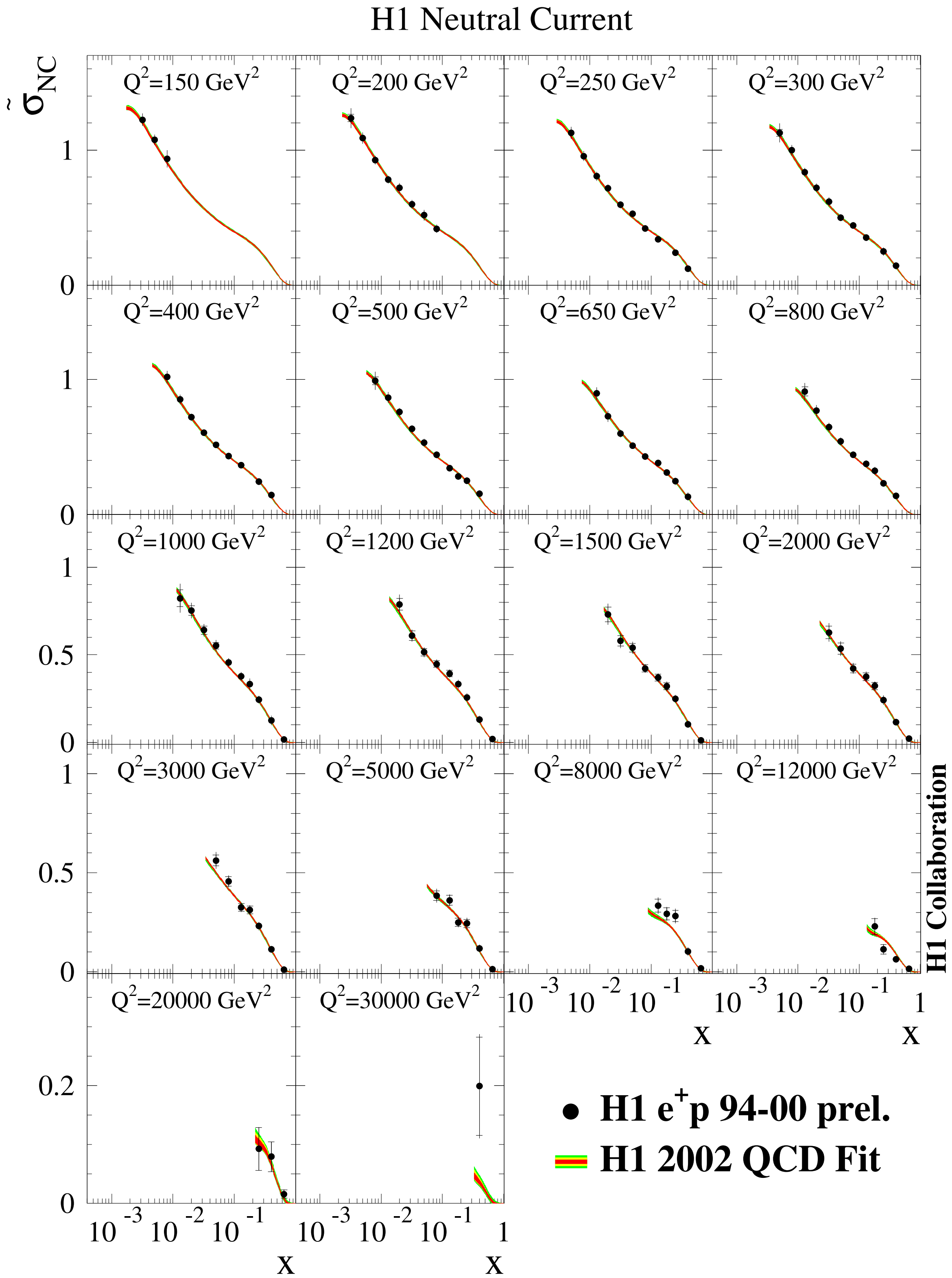
- Starting point: three parameters (a, b, c) for each PDF.
- Add one additional parameter for one PDF for already accepted fit
- Accept new parametric form if,
  - fit is able to constrain new parameter (error matrix positive definite)
  - χ^2 is improved by more than 1 unit
- All fits with $\Delta\chi^2 = \chi^2 - \chi^2{}_{\text{(best)}} \leq \sqrt{2N_{\text{dof}}}$ contribute to envelope

Results for starting scale $Q_0^2 = 4\ \text{GeV}^2$:

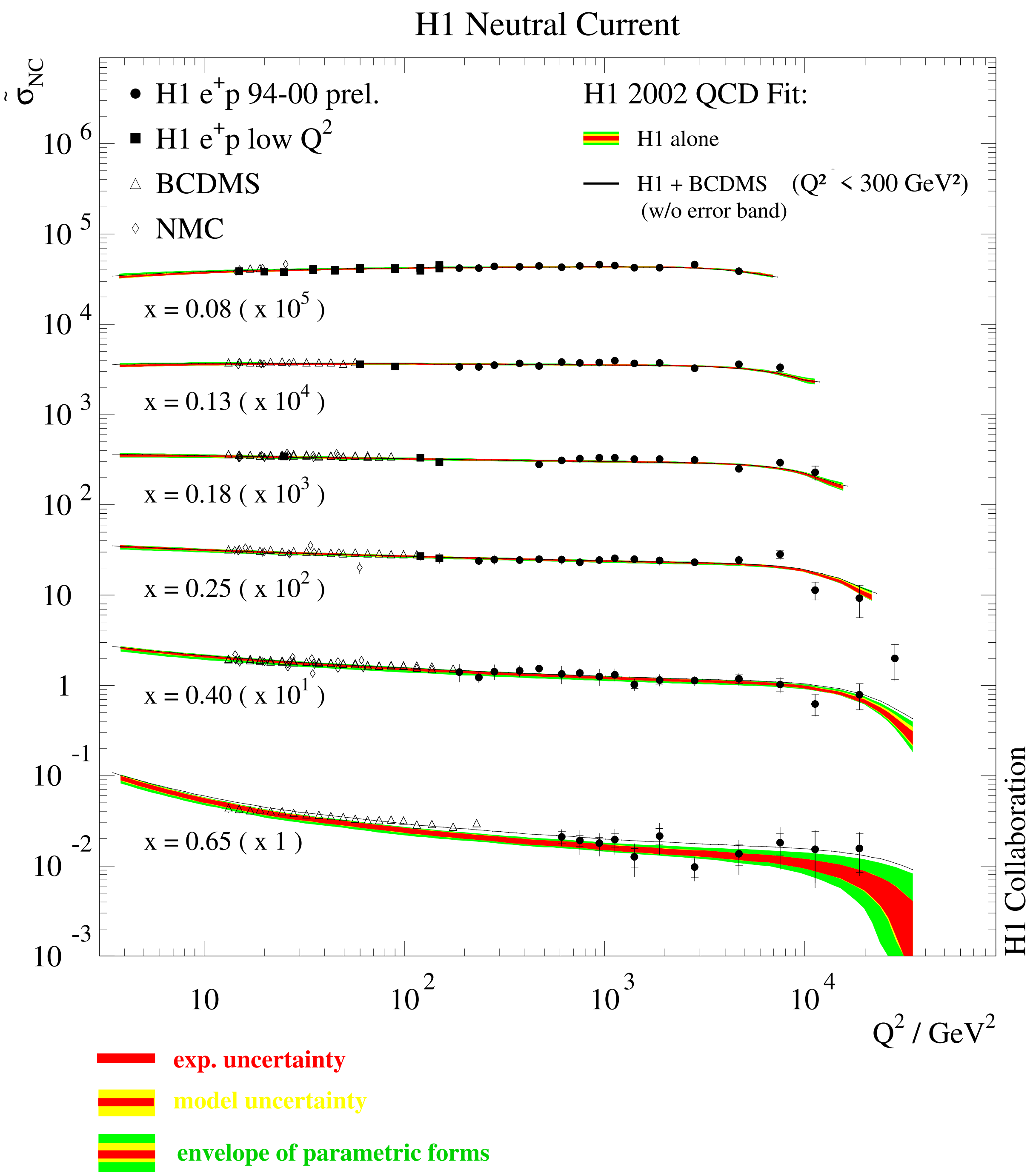
$x\,g$	$x\,u_v$	$x\,d_v$	$x\,Sea$
1	1	1	1
$1+d\,\sqrt{x}$	–	–	$1+d\,\sqrt{x}$
$1+e\,x$	$1+e\,x$	–	$1+e\,x$
$(1+d\,\sqrt{x}+e\,x)$	$1+d\,\sqrt{x}+e\,x$		–

central fit: best $\chi^2 = 532$ for 621 data points
$\Delta\chi^2 = \chi^2_{\text{(most simple)}} - \chi^2{}_{\text{(best)}} =\simeq 20$ units
$\Longrightarrow$ keep all sucessful fits (23) for envelope

NC Cross Sections

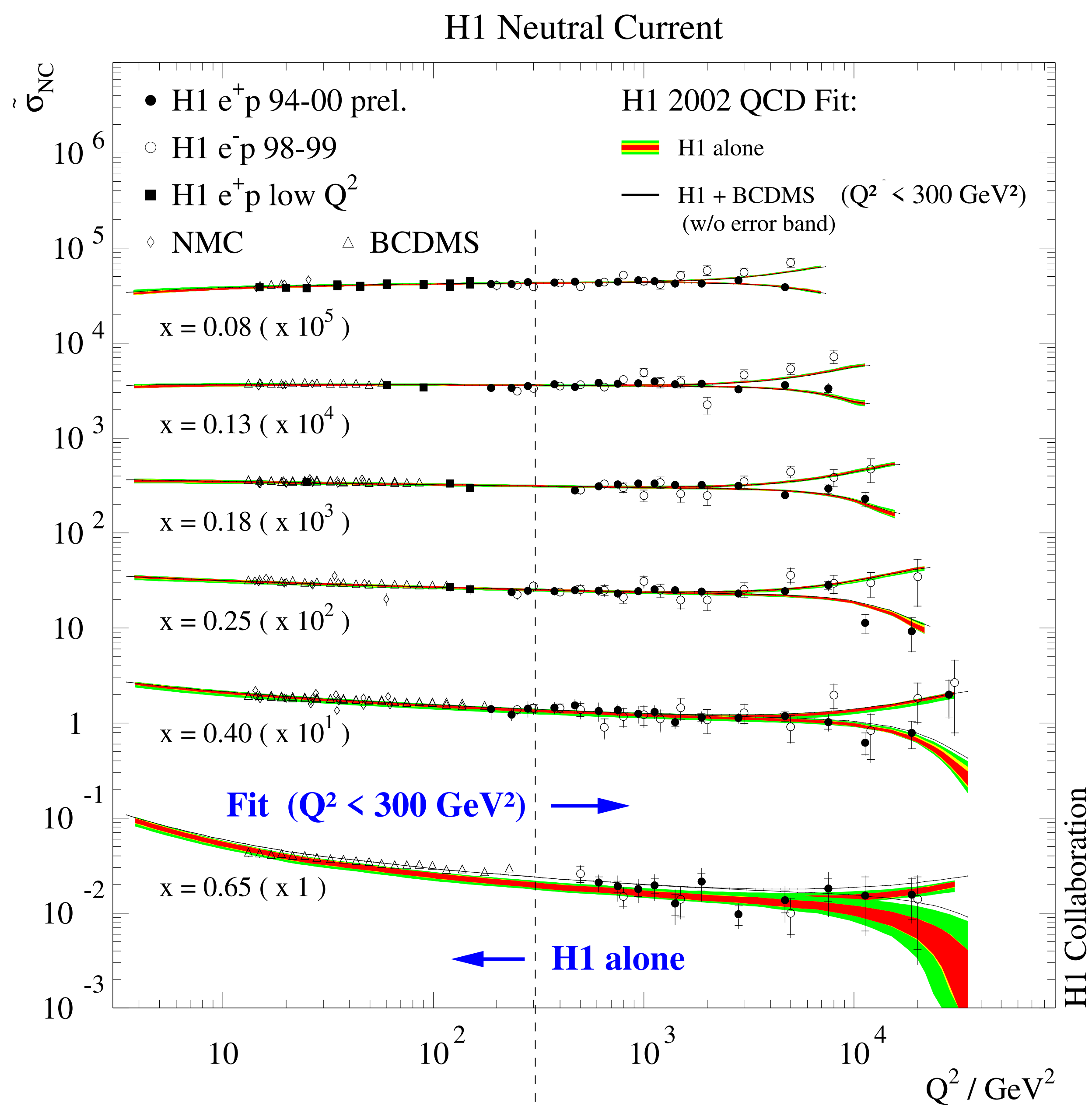


NC Cross Section at high x



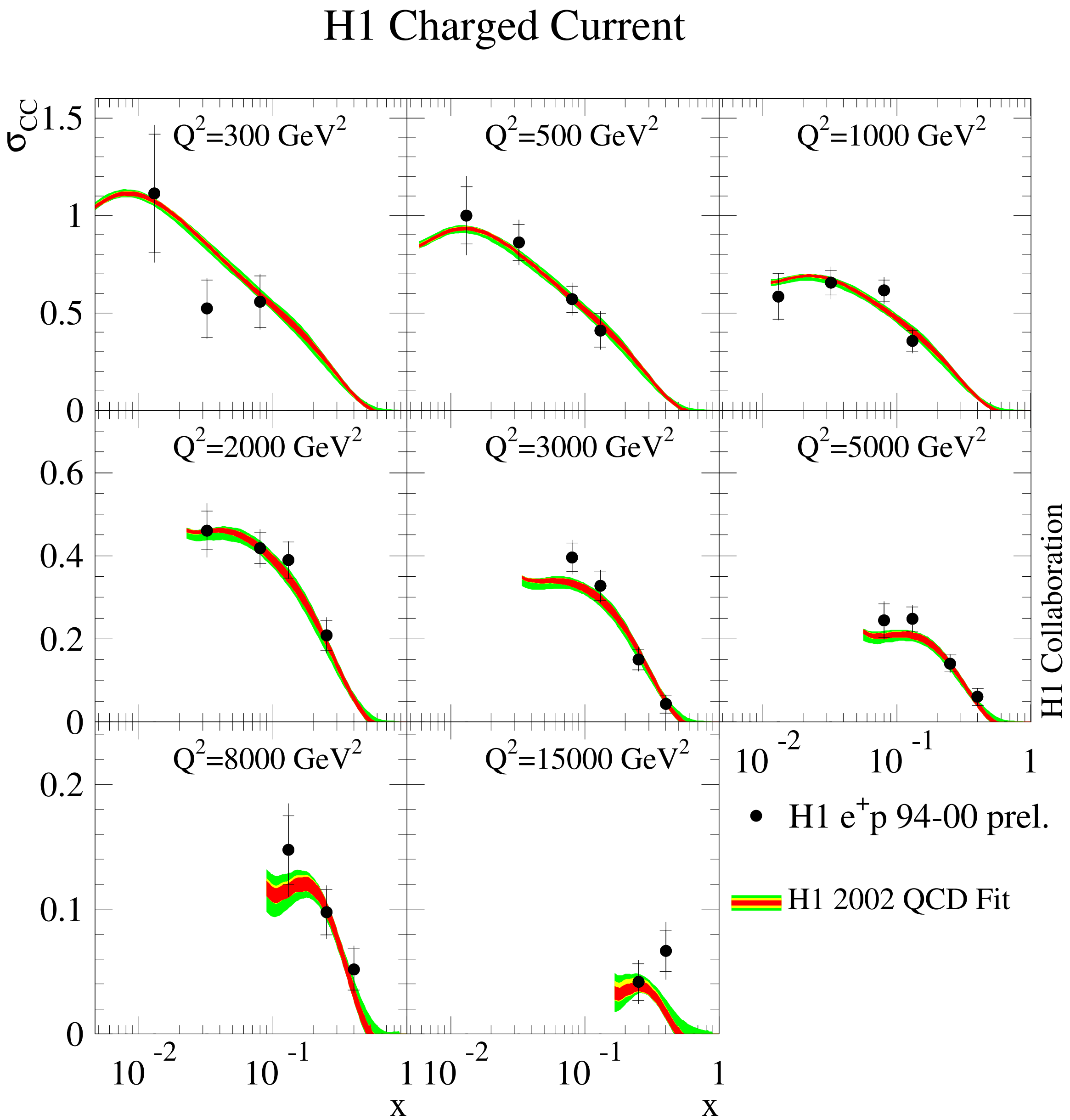
envelope: spread of possible solutions

NC Cross Section: e^+p & e^-p

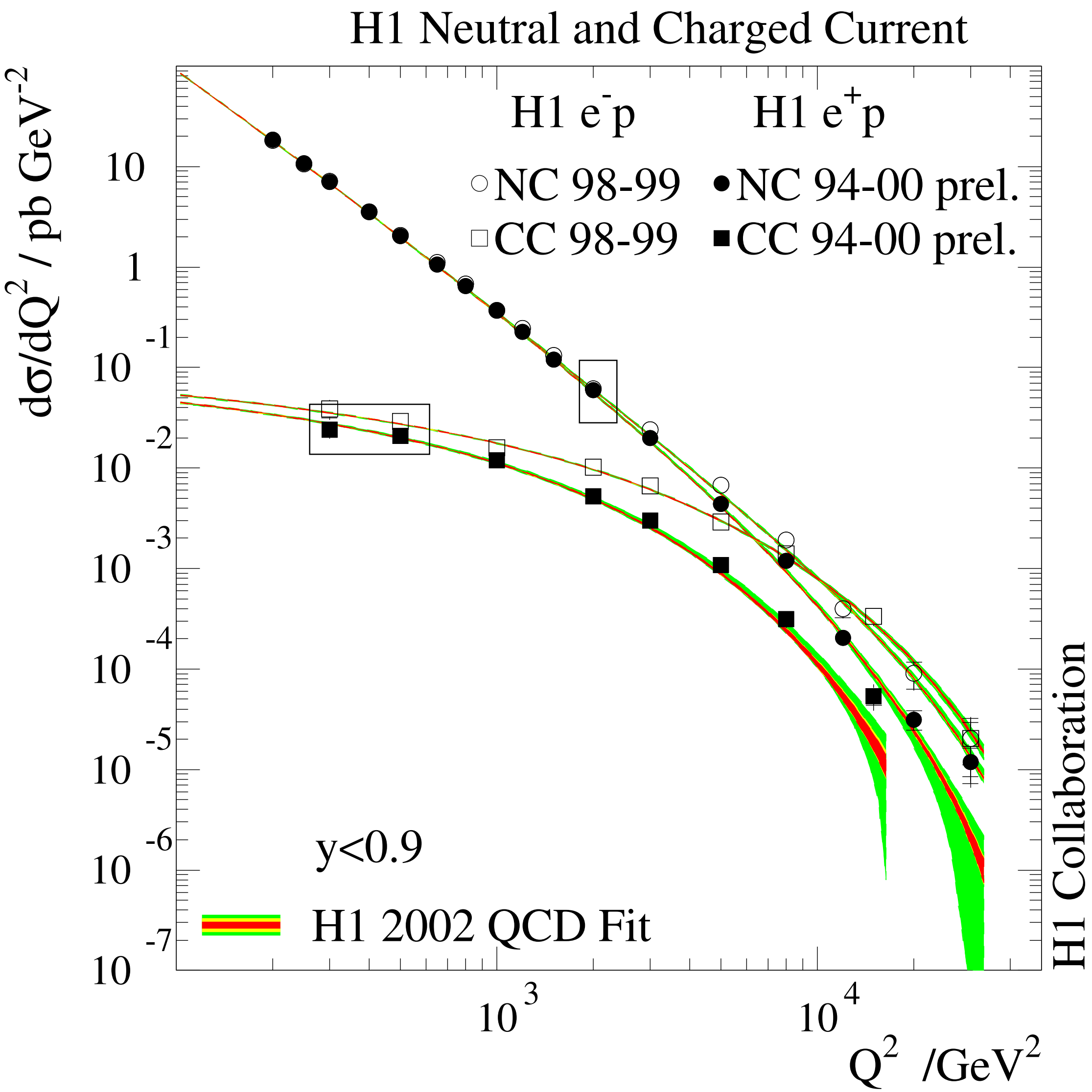


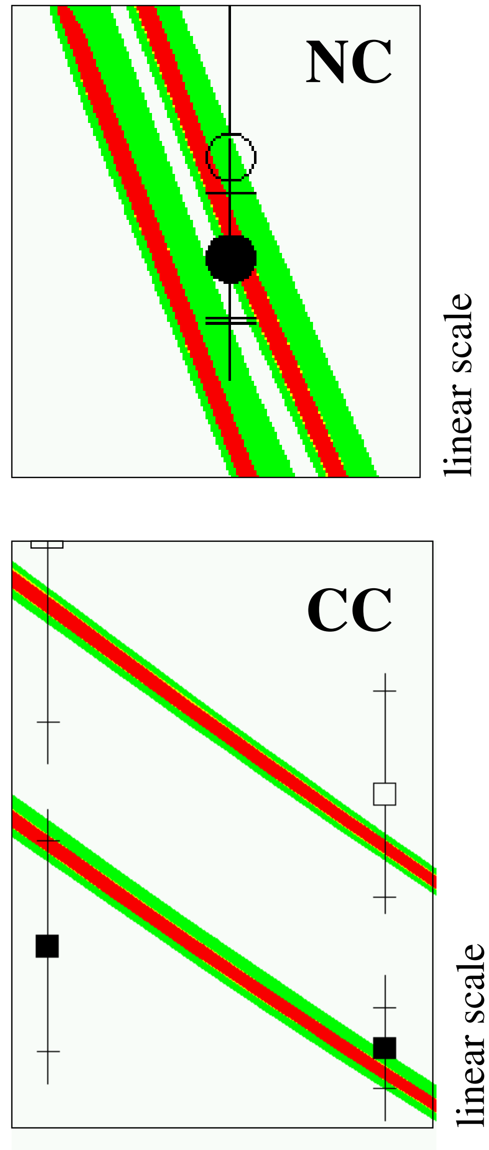
- H1 alone predicts fixed target data
- H1 & BCDMS $p + d$ ($Q^2 < 300$ GeV^2) describes high Q^2 data

CC Cross Section



Cross sections $d\sigma/dQ^2$: NC & CC, e^+p & e^-p





Summary

- H1 QCD Fits follow two complementary approaches
  - dedicated fits to answer specific questions
    $\alpha_s + gluon$
  - general fits
    aiming for PDFs with uncertainty bands

- "How to present uncertainties?"
  - "experimental" band
  - "model" band
  - "envelope" variation of parametric forms

- Even for integrated cross sections at moderate Q^2 variation of parametric forms is visible.