H-L. Lai (I) 1

# Recent Global Analyses by CTEQ

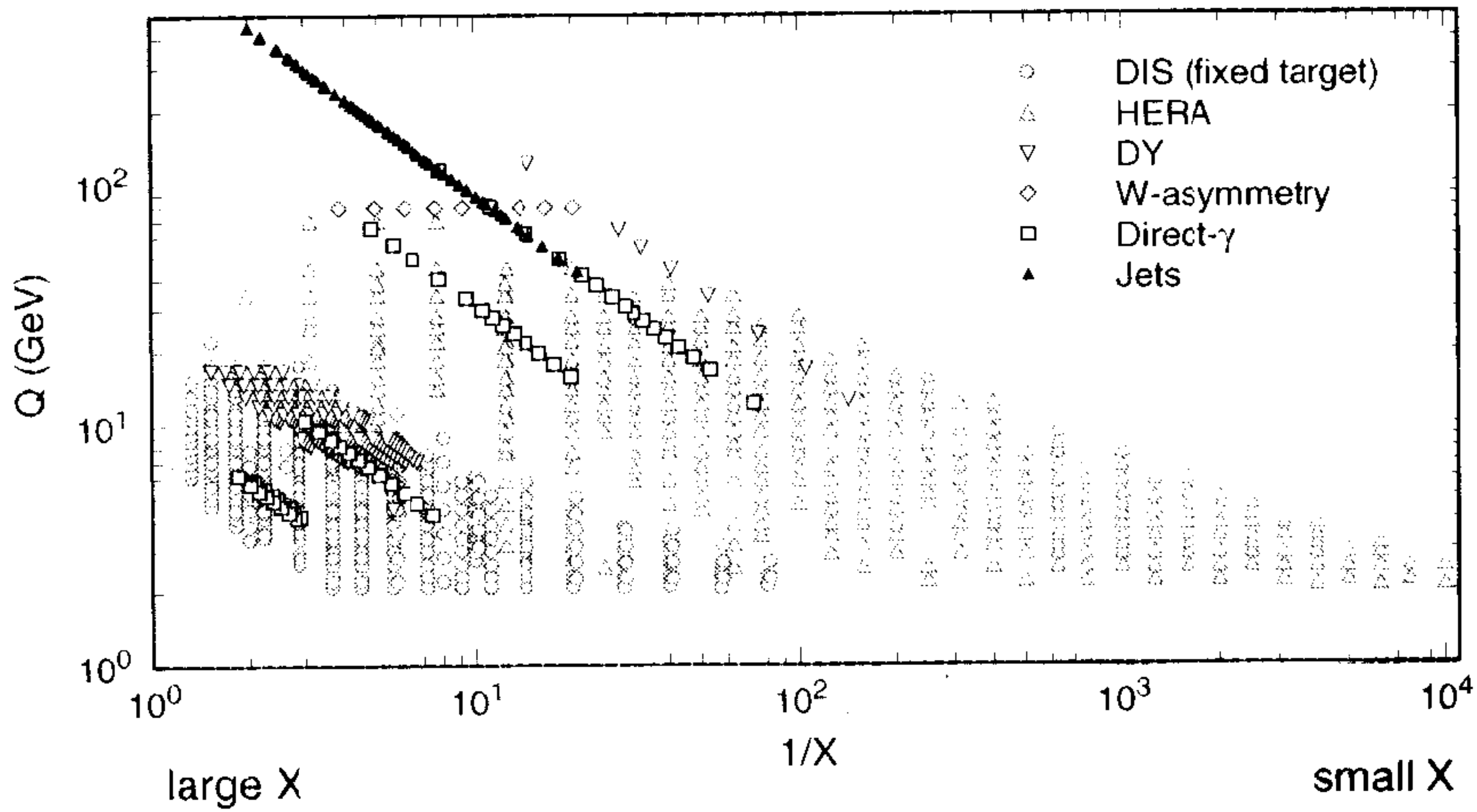
- Recent CTEQ global analyses incorporating charm mass effects, motivated by precision HERA measurements on $F_2$ and $F_2^c$

hep-ph/9701256, to appear in Z. Phys.

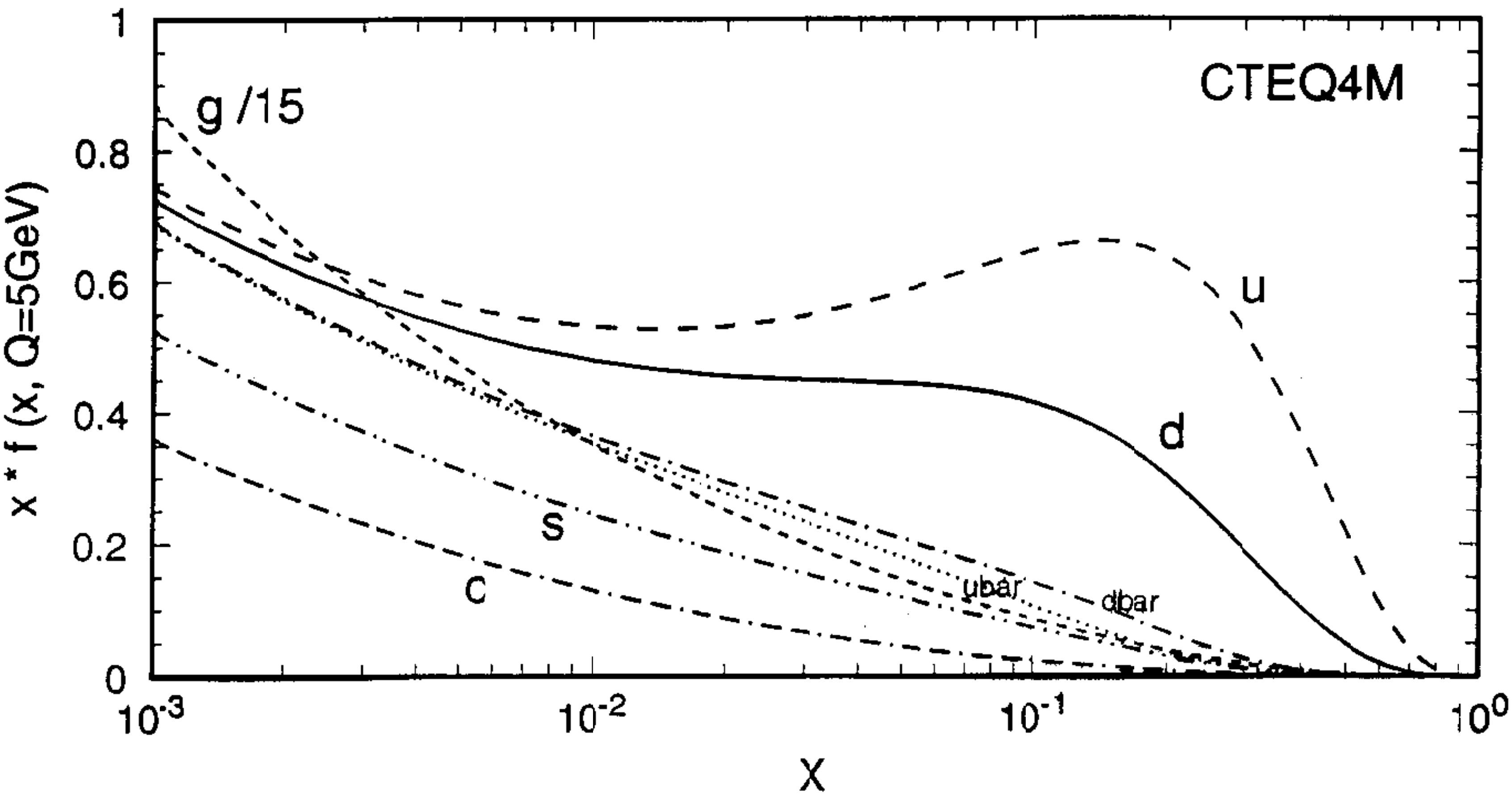
- Preliminary studies on possible impact of recent data from CCFR and CDF W-lepton asymmetry on parton distribution analyses

# Experimental Input

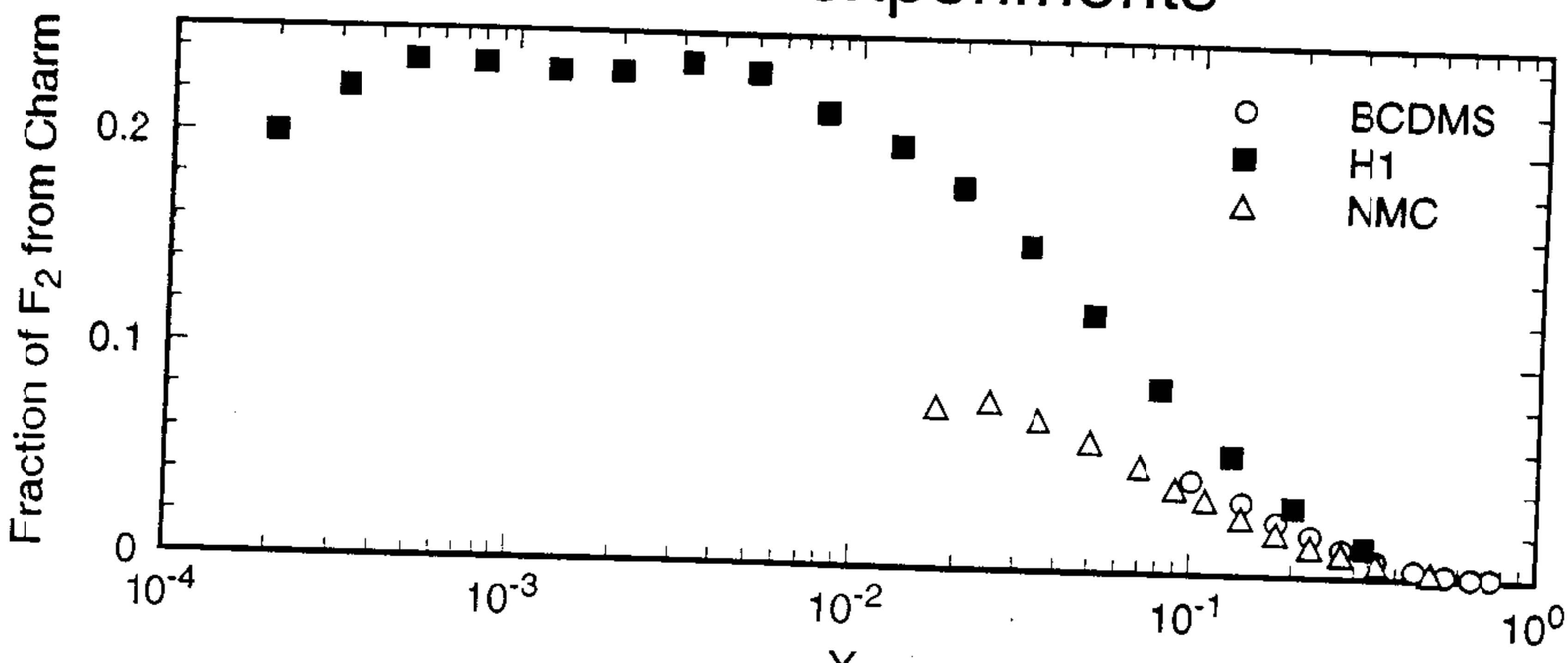
## Distribution of data points on X-Q kinematic map



# Behavior of typical Parton Distributions at $Q^2 = 25\ GeV^2$



# Fraction of $F_2$ from Charm Contribution in various experiments




* The data shown are calculated using CTEQ4M with average on the Q bins of that particular experiments at fixed x.

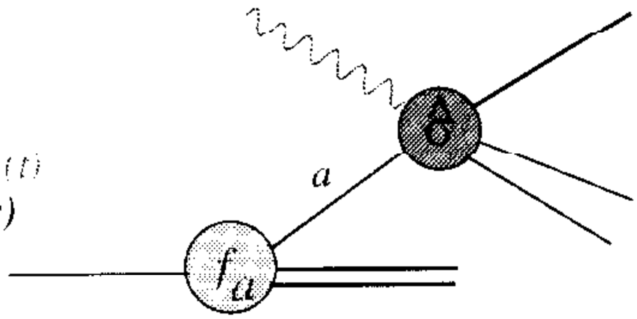
# Theoretical Framework

## Conventional PDF analysis:

### Zero-mass Parton Factorization Formula

$$\sum_{a = g, u, d, s, c, b, (t)}$$

*(all active flavors)*




*All quark masses = 0 in* $\hat{\sigma}$ *(MSbar Subtr.)*

*This theory is valid for* $m_H << Q$ ***but*** *is not good for* $m_H \sim Q$.

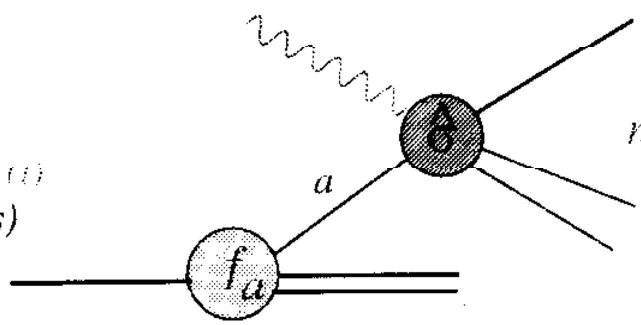
## New global analysis including effects of heavy quark mass:

### Generalized Factorization Formula

Aivazis, Collins, Olness, Tung (ACOT)

$$\sum_{a = g, u, d, s, c, b, (t)}$$

*(all active flavors)*



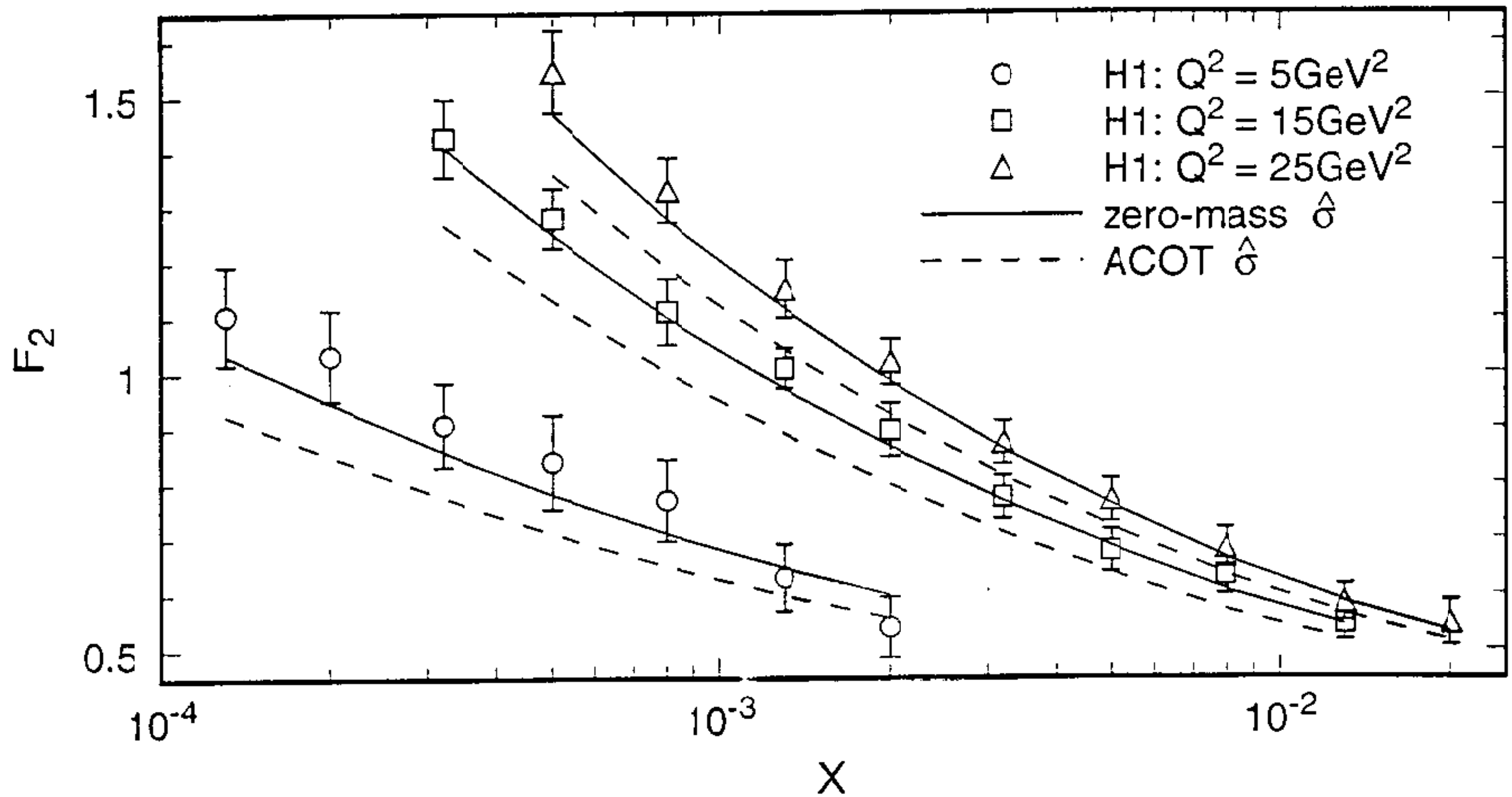

*heavy quark masses* $\neq 0$ *in* $\hat{\sigma}$ *(Mass Subtr.)*

*With mass subtraction, this theory is valid in the full range from* $m_H \sim Q$ *to* $m_H << Q$.

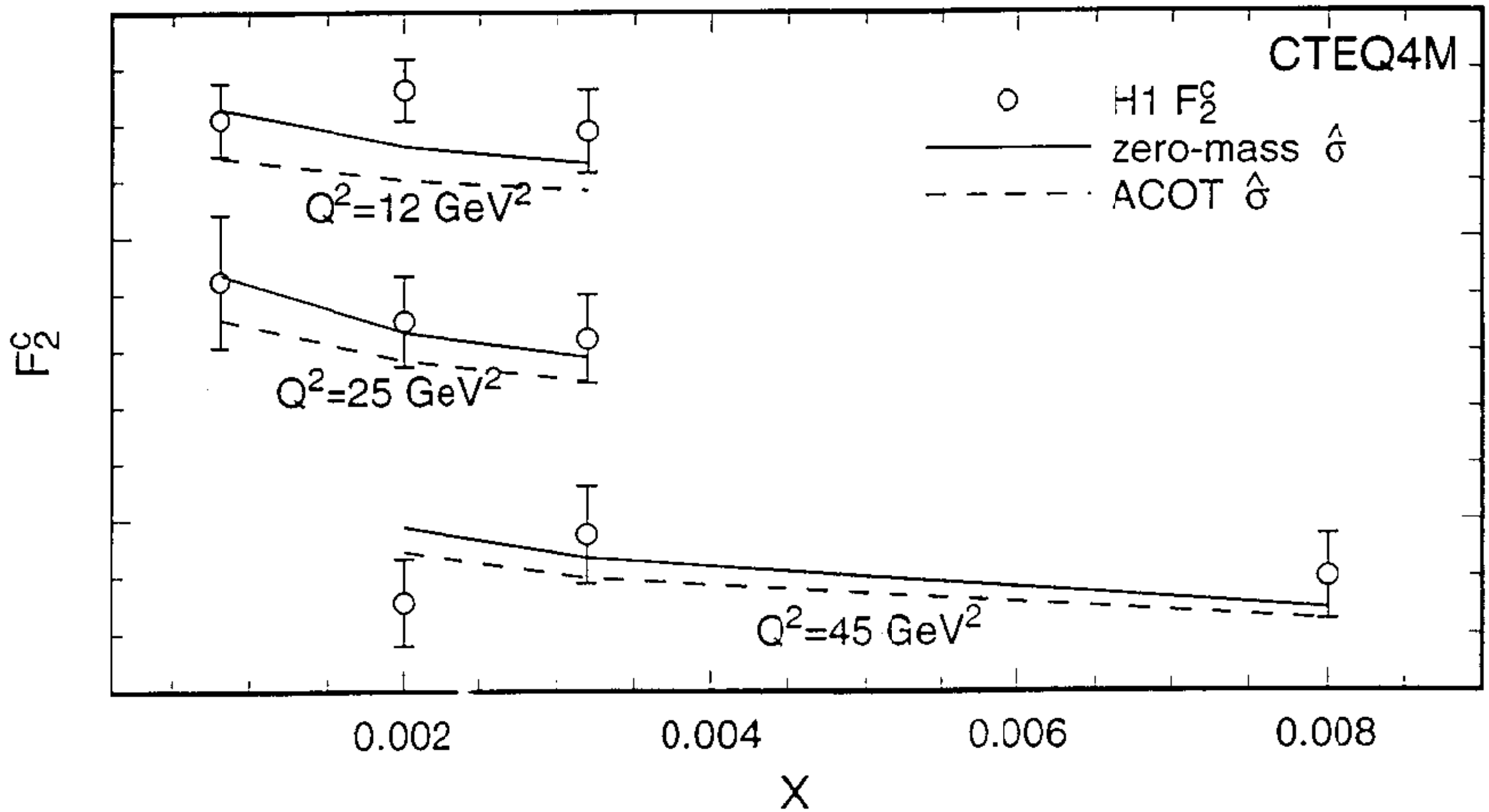
Differences due to

## Charm mass effects in $\hat{\sigma}$

using the same PDFs (CTEQ4M)

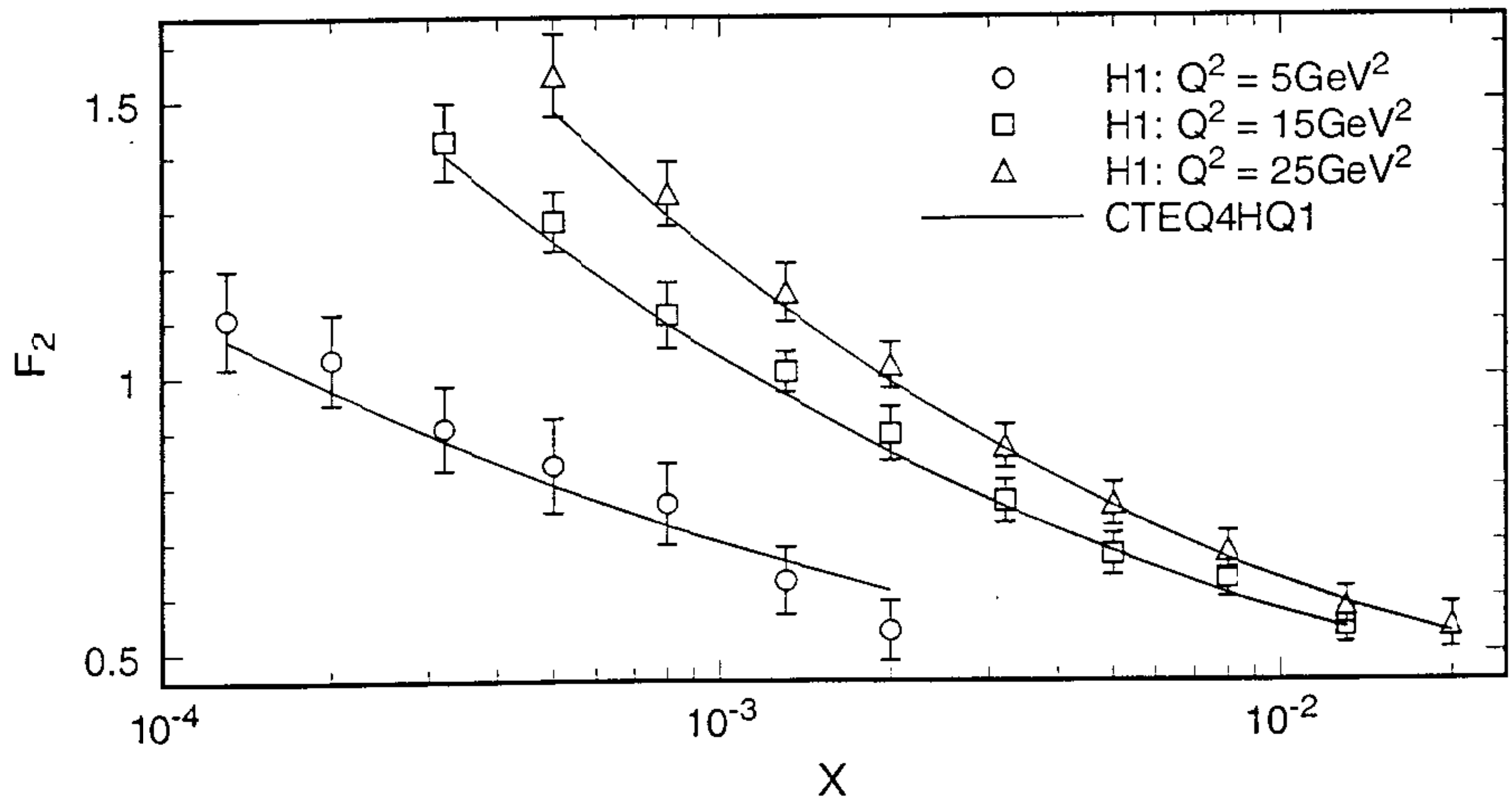


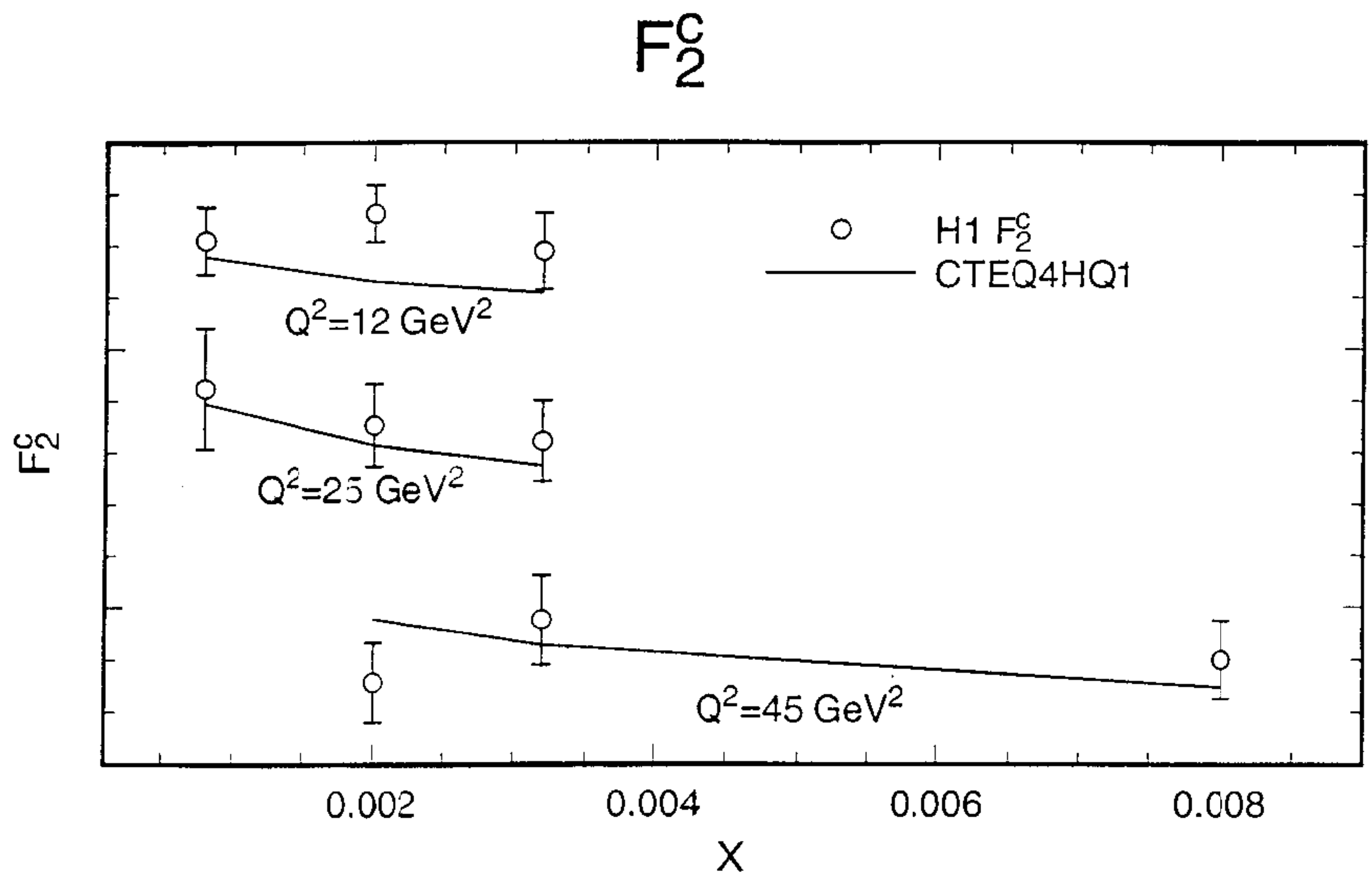
$F_2^c$



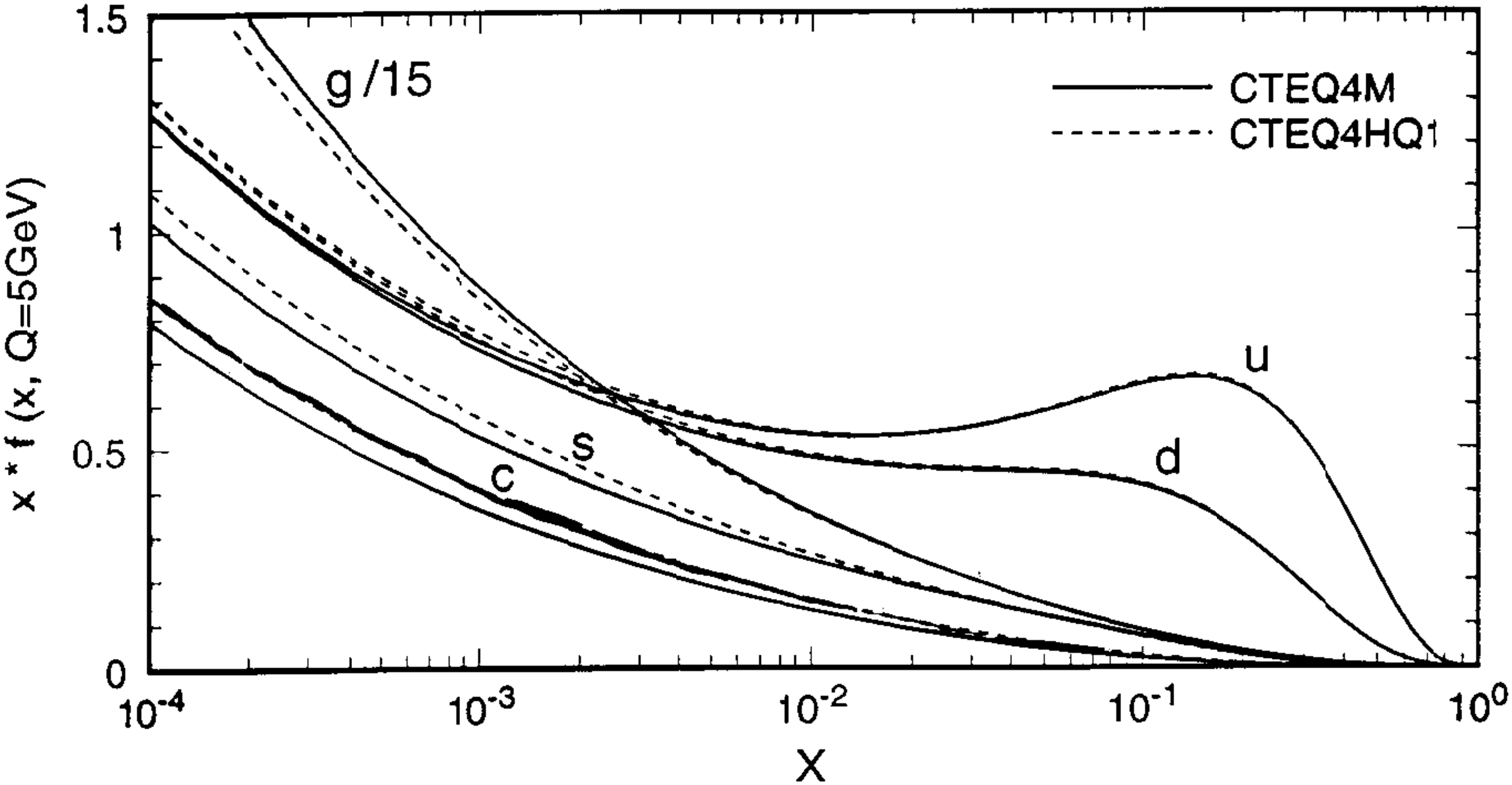
CTEQ4M
H1 $F_2^c$
zero-mass $\hat{\sigma}$
ACOT $\hat{\sigma}$
$Q^2$=12 GeV$^2$
$Q^2$=25 GeV$^2$
$Q^2$=45 GeV$^2$
$F_2^c$
0.002
0.004
0.006
0.008
X

# New global fit — CTEQ4HQ1 based on the ACOT scheme



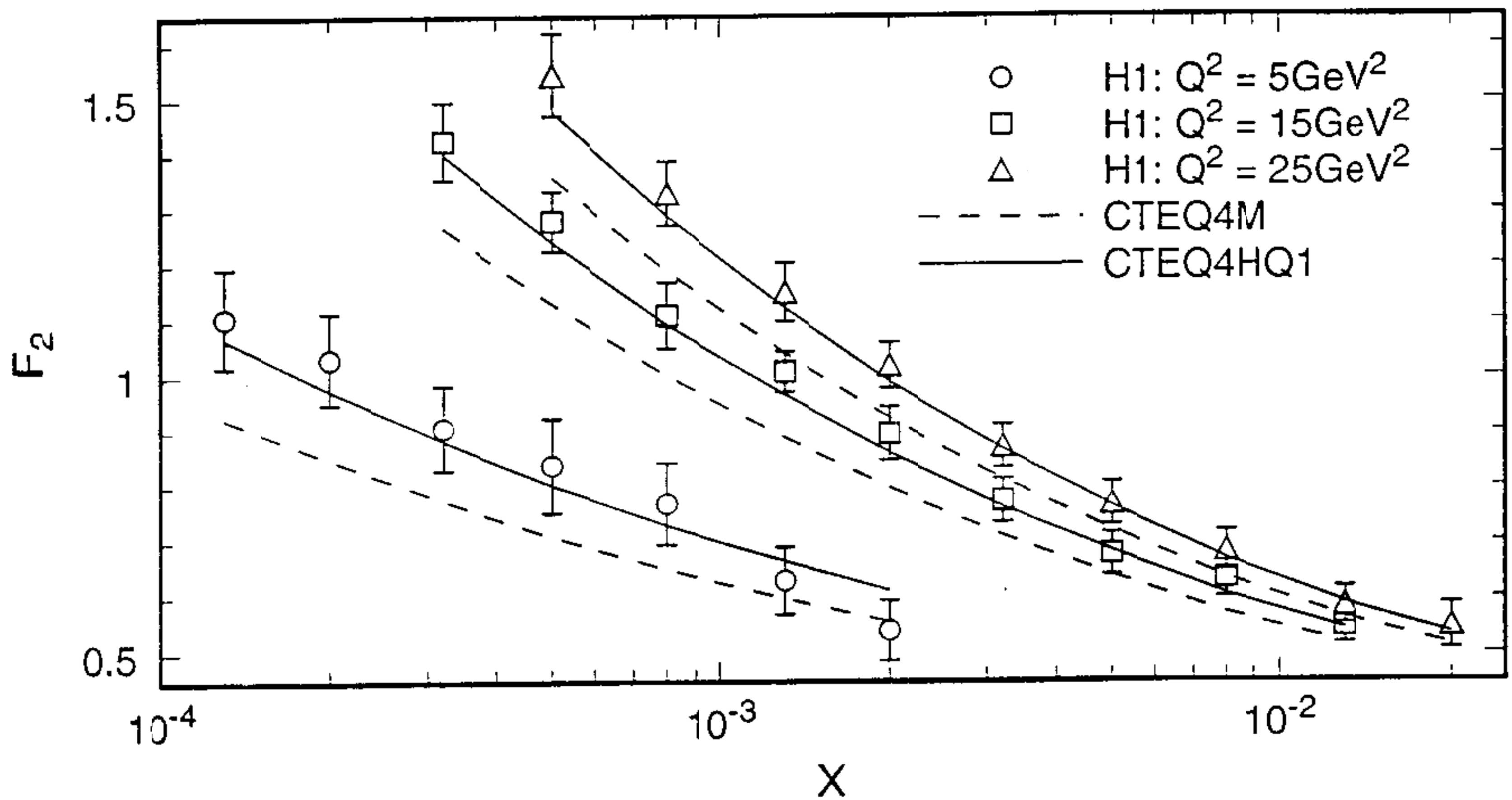

$F_2^c$
H1 $F_2^c$
CTEQ4HQ1
$Q^2$=12 GeV$^2$
$Q^2$=25 GeV$^2$
$Q^2$=45 GeV$^2$
$F_2^c$
0.002
0.004
0.006
0.008
X

# Change in PDFs due to different treatment of $M_c$



Differences due to

# PDF sets by applying the same ACOT $\hat{\sigma}$



# Comparison of the Quality of new global fits CTEQ4HQ1 with CTEQ4M

| Expt. | #pts | CTEQ4M | CTEQ4HQ1 |
|---|---|---|---|
| $BCDMS$<br>$NMC$<br>$E665$ | 691 | 725 | 716 |
| $CCFR$ | 126 | 130 | 118 |
| $HERA$ | 351 | 362 | 354 |
| $CDF A_W$ | 9 | 4 | 4 |
| $NA51$ | 1 | 0.6 | 0.2 |
| $E605$ | 119 | 98 | 99 |
| Total | 1297 | 1320 | 1291 |

# Preliminary studies on possible impact of recent data from CCFR and CDF W-lepton asymmetry on Parton Distribution Analyses

- Final CCFR data on $F_2$ and $F_3$ structure functions have become available.

  see previous talk

- What is the impact on the PDF analysis, particularly on the strange quark?

LO Formula: (u, d and s only)

$$F_2^{\mu p} = x[4(u+\overline{u}) + (d+d) + 2s]/9$$

$$F_2^{\mu n} = x[4(d+\overline{d}) + (u+\overline{u}) + 2s]/9$$

$$F_2^{\nu N} = F_2^{\overline{\nu} N} = x[(u+\overline{u}) + (d+\overline{d}) + 2s]$$

The strange quark distribution is sensitive to:

$$\frac{5}{6}F_2^{\nu N} \quad - 3F_2^{\mu N} \quad = xS$$

(CCFR) (NMC, BCDMS)

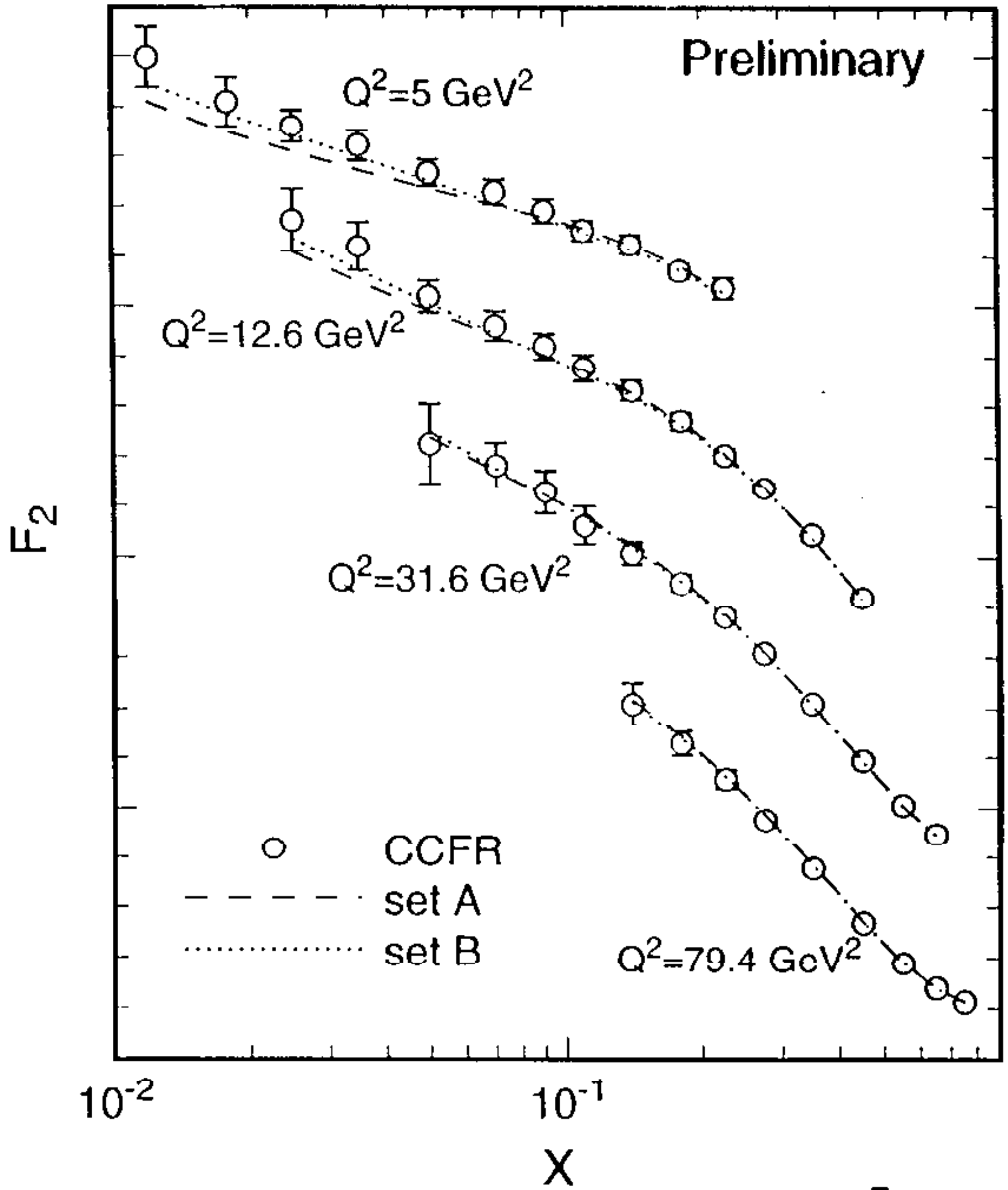
It is also "directly" measureable in:

$$d\sigma(\nu N \to \mu^+\mu^- X) \sim xS$$

(CDHS, CCFR, CHARM)

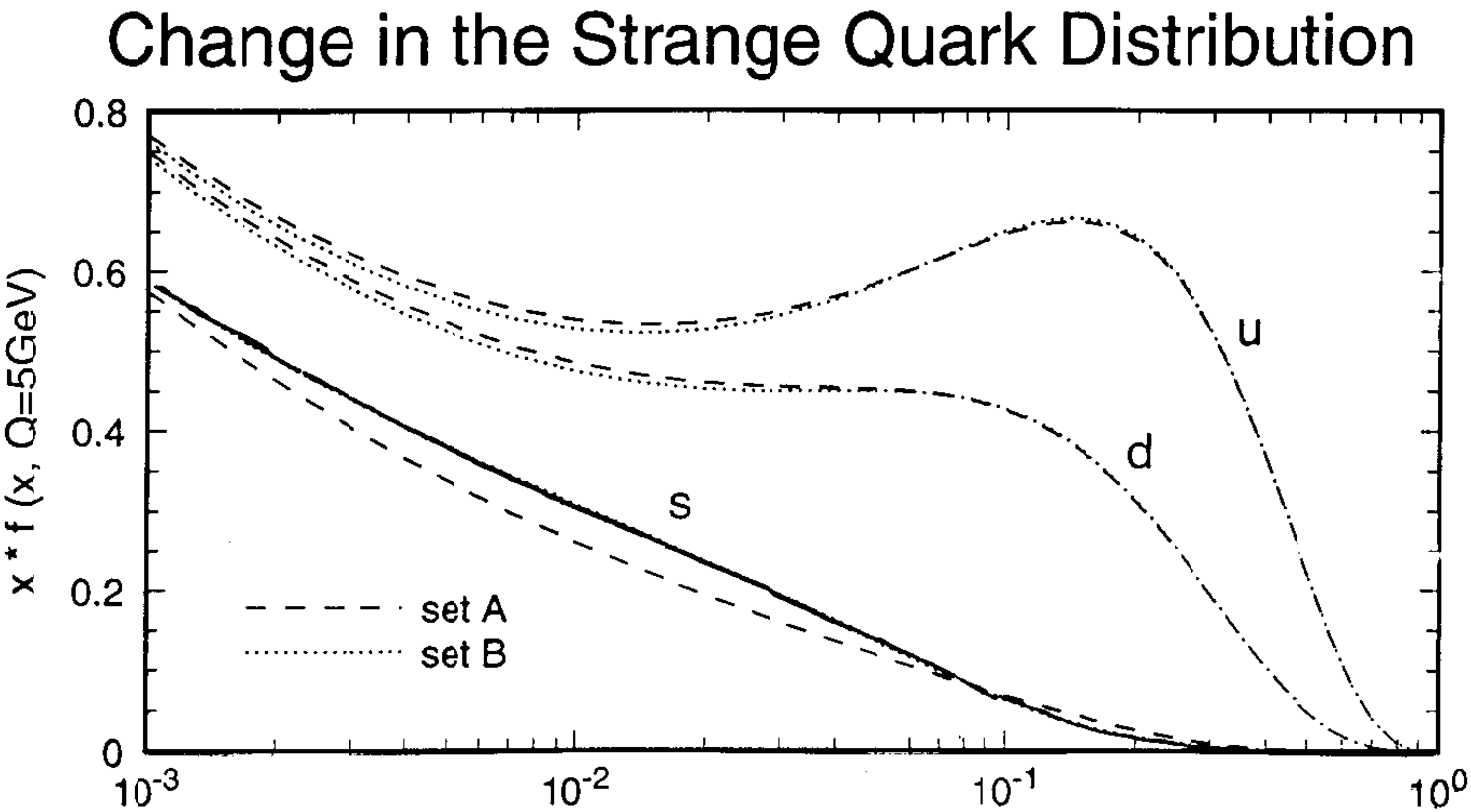
$$S = \kappa \frac{\bar{u} + \bar{d}}{2} \ ?$$

(Suggested by $\mu^+\mu^-$ data, $\kappa \sim 0.45\text{-}0.5$)




Set A: constraint $S = \kappa \frac{\bar{u} + \bar{d}}{2}$

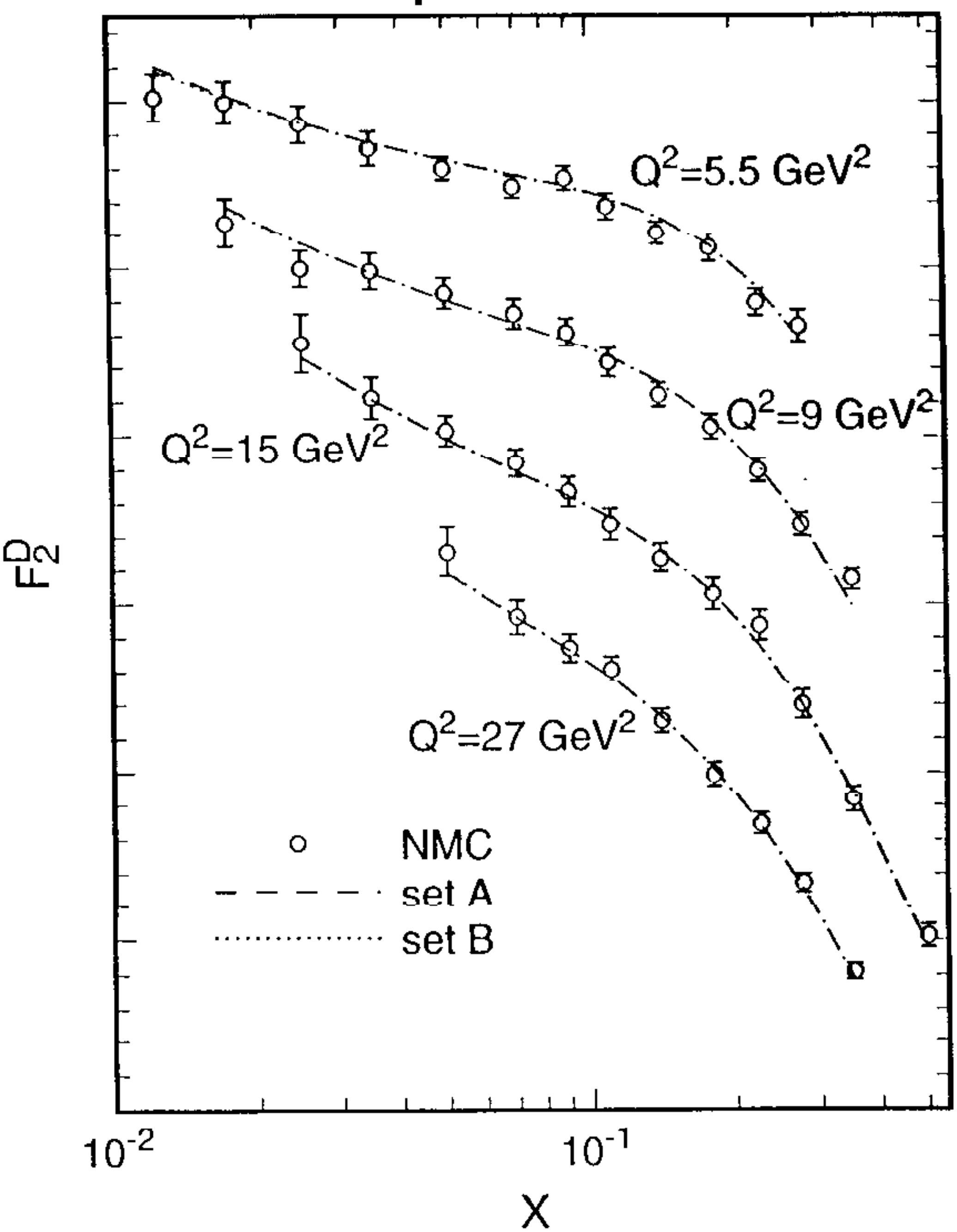
Set B: no constraint on shape of s




Set A: constraint $s = \kappa \frac{\bar{u} + \bar{d}}{2}$

Set B: no constraint on shape of s

# Are CCFR & NMC data compatible ?




* Both sets fit NMC data well.

* Set A is preferred by dimuon data.
  — Does it give an "acceptable" fit to CCFR $F_2$ at the small $x$ region?

* Set B is preferred by CCFR $F_2$ at the small $x$ region.
  — Is it acceptable by the dimuon data?

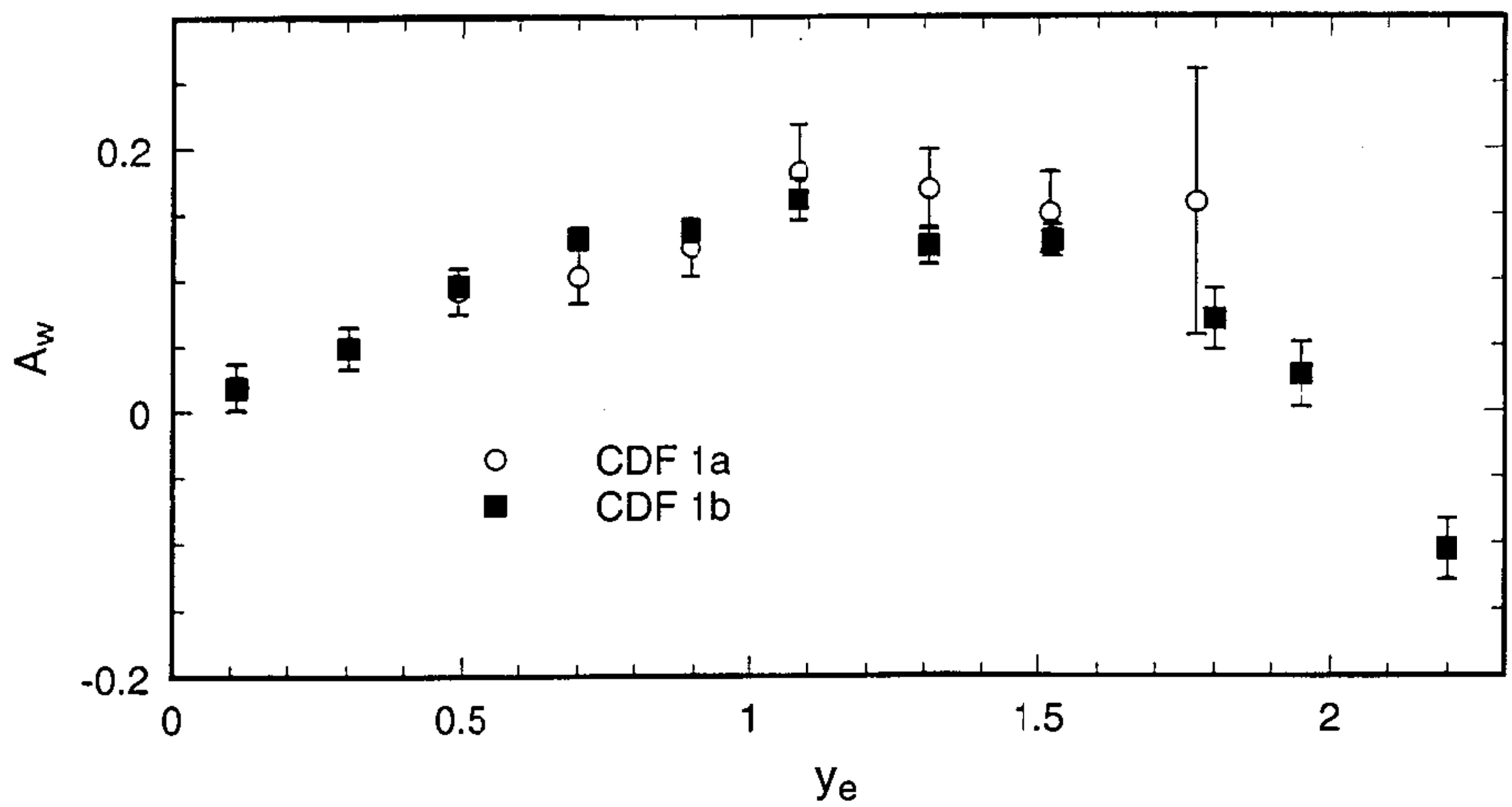
# Lepton Forward-Backward Asymmetry in $W$ Production at the Tevatron

- The CDF run 1a data had an important influence on the previous global analyses

- Run 1b data :
  - smaller errors
  - extended $y$ range

- What do 1b data tell us about PDFs in PQCD?

# Comparison of CDF Run 1a/1b data



LO Approximation, u and d only:

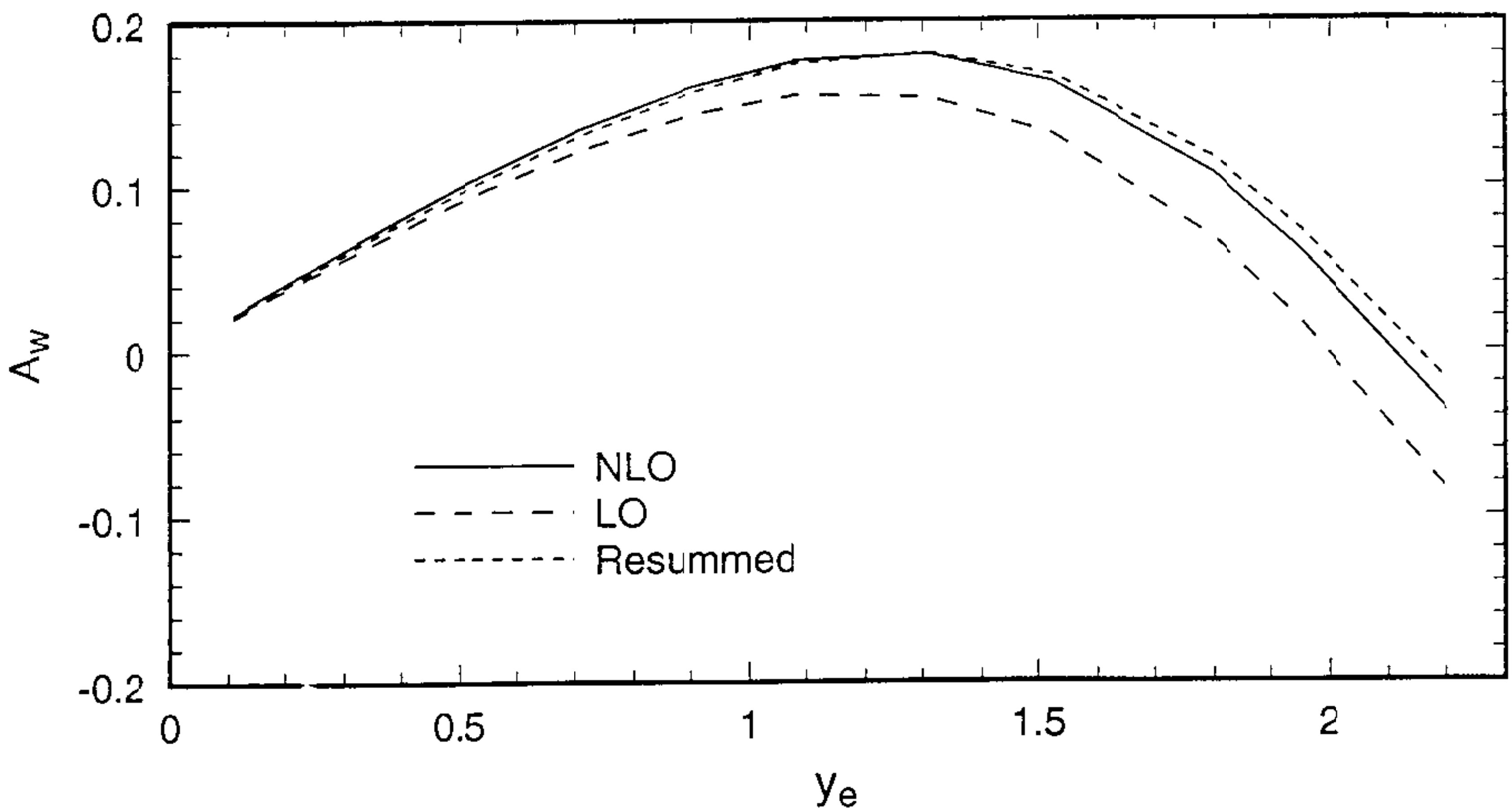
$$A_W(y) = \frac{d\sigma^+/dy - d\sigma^-/dy}{d\sigma^+/dy + d\sigma^-/dy} \qquad (1)$$

$$A_W(y) \approx \frac{u(x_1)d(x_2) - d(x_1)u(x_2)}{u(x_1)d(x_2) + d(x_1)u(x_2)} \qquad (2)$$

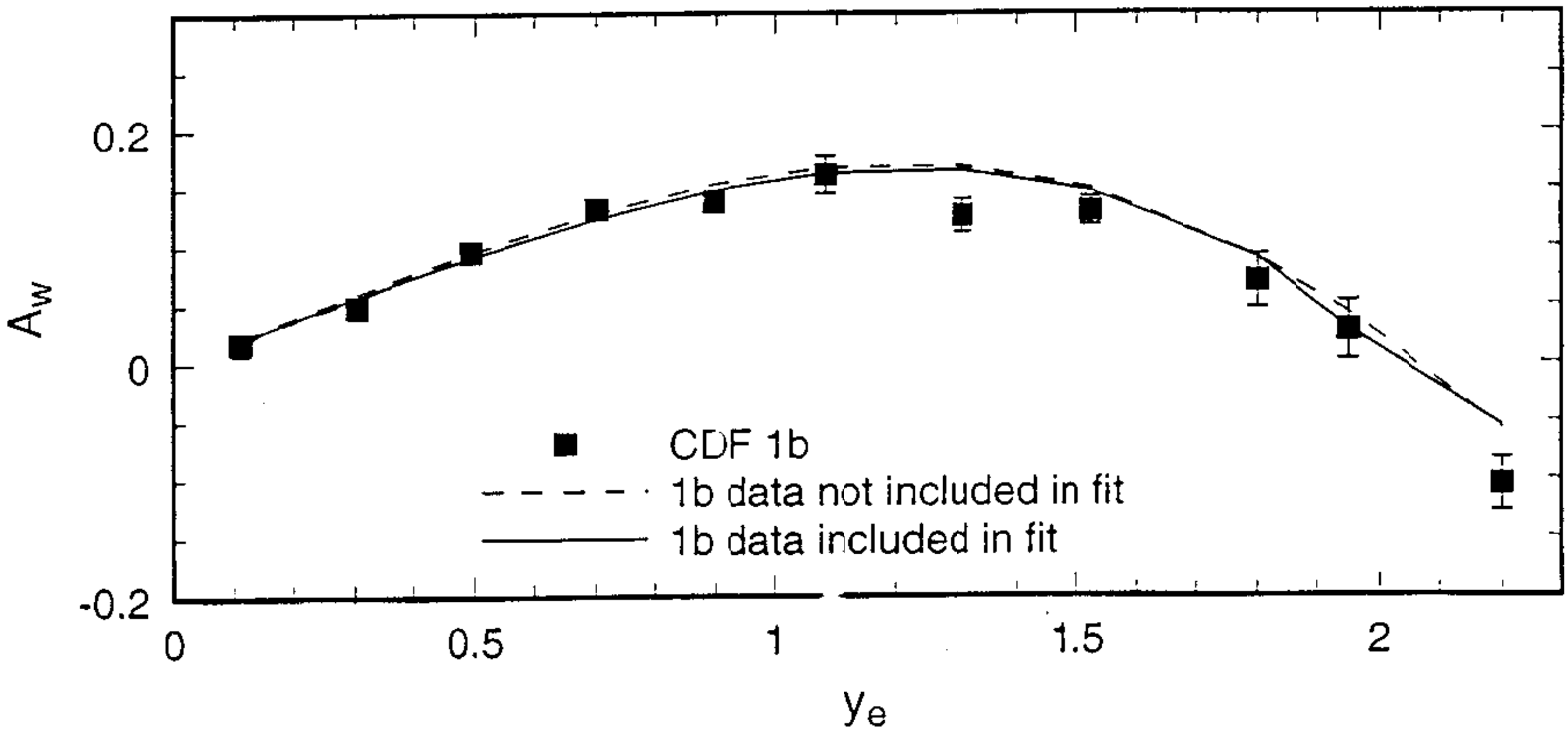
where $x_{1,2} = x_0 e^{\pm y}$ and $x_0 = M_w/\sqrt{s}$.
Letting $R(x) = d(x)/u(x)$, one can write

$$A_W(y) = \frac{R(x_2) - R(x_1)}{R(x_2) + R(x_1)}. \qquad (3)$$

# Are NLO and/or Resummed formalism needed in W-lepton asymmetry calculations?

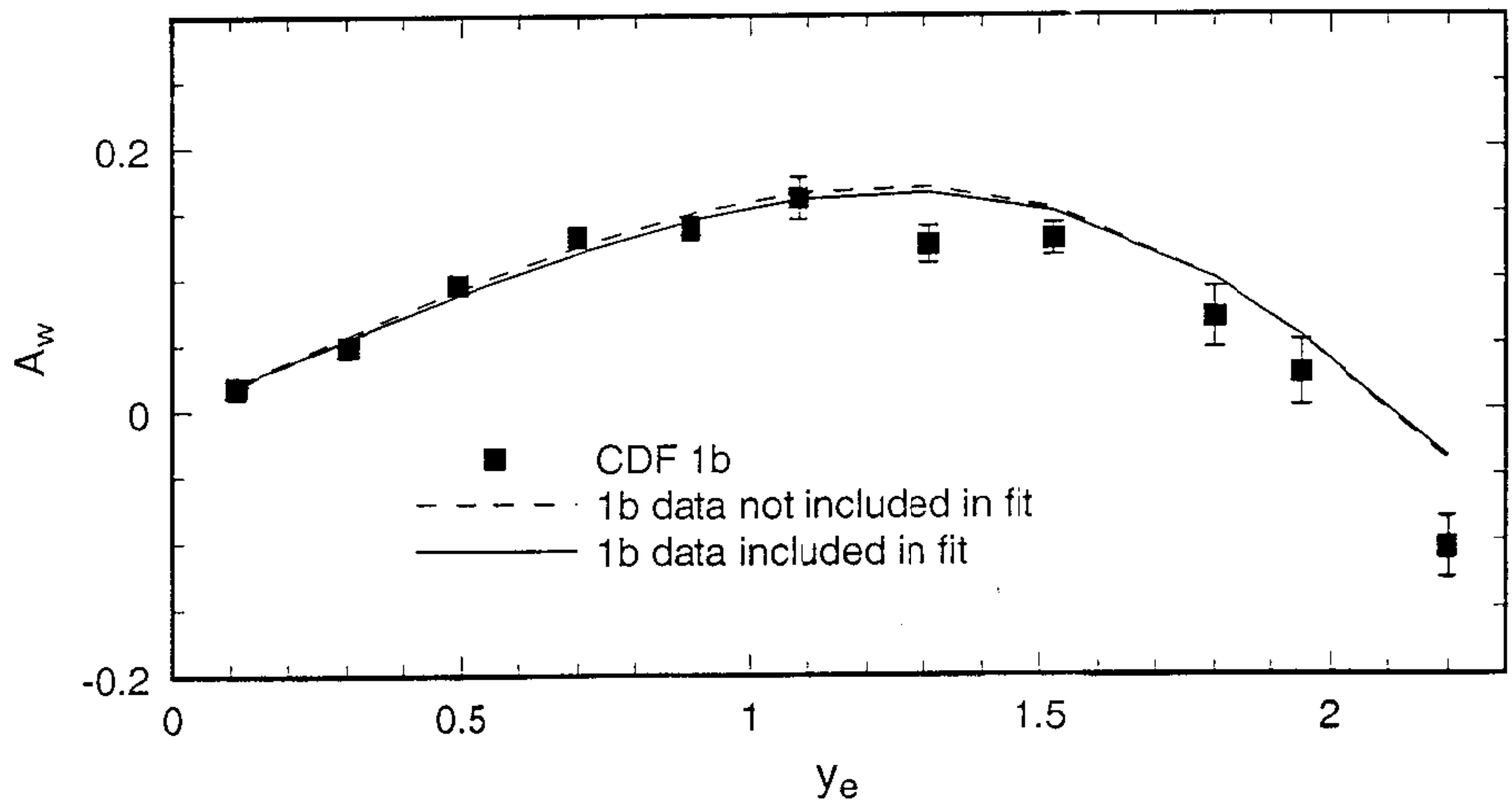


# Comparison of CDF Run 1b data to two fits using NLO QCD




* Fits using 1a data only also describe 1b data well.

## Comparison of CDF Run 1b data to two fits using Resummed QCD



# Conclusions

- Heavy quark mass effects on DIS measurements
  - differences between the massless and massive calculations of DIS $\hat{\sigma}$ appear to be significant in the small x, low Q region.
  - more complete theoretical treatment does give slightly better agreement with experiments.
  - ACOT scheme requires a larger charm quark distribution.
- Impact of the final CCFR $F_2$ and $F_3$ data
  - still seems to prefer a larger strange quark distribution in the medium x range.
  - compatibility with dimuon and NMC data needs further study.
- What can the CDF 1b data on W-lepton asymmetry say about PDFs and PQCD?
  - there is little effect on PDFs as compared to 1a data.
  - it is harder to accommodate 1b data over the extended $y$ range using resummed vs. NLO QCD formula.