Recent Structure Functions results from $\nu - N$ scattering at Fermilab

Un-Ki Yang [1]
University of Rochester
(Currently in University of Chicago)
CCFR-NuTeV Collaboration

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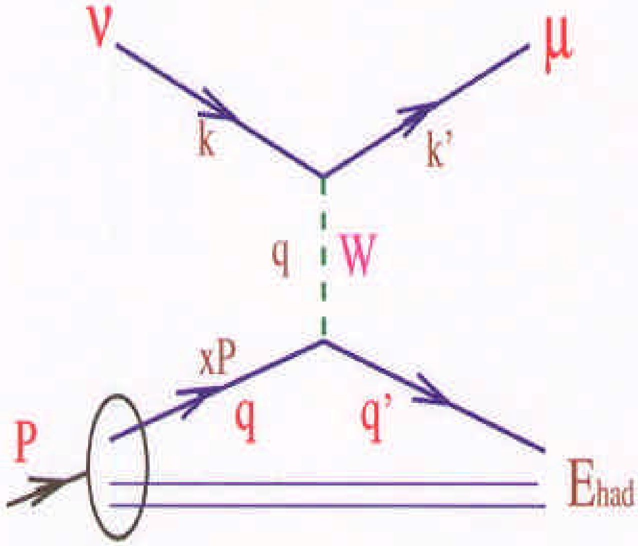
Outline

1. Current issues relating to F_2^ν, xF_3^ν-$xF_3^{\bar{\nu}}$
2. A physics model independent (PMI) analysis
3. Current issues relating R and the HERMES effect
4. Conclusions and future prospects from NuTeV

[1] Ph.D thesis work in Univ. of Rochester

Deep inelastic $\nu - N$ scattering



3 indep. kinematic variables

$Q^2 = -q^2 = -(k-k')^2$
(four momentum transfer)

$x = Q^2 / 2ME_{had}$
(fractional quark momentum)

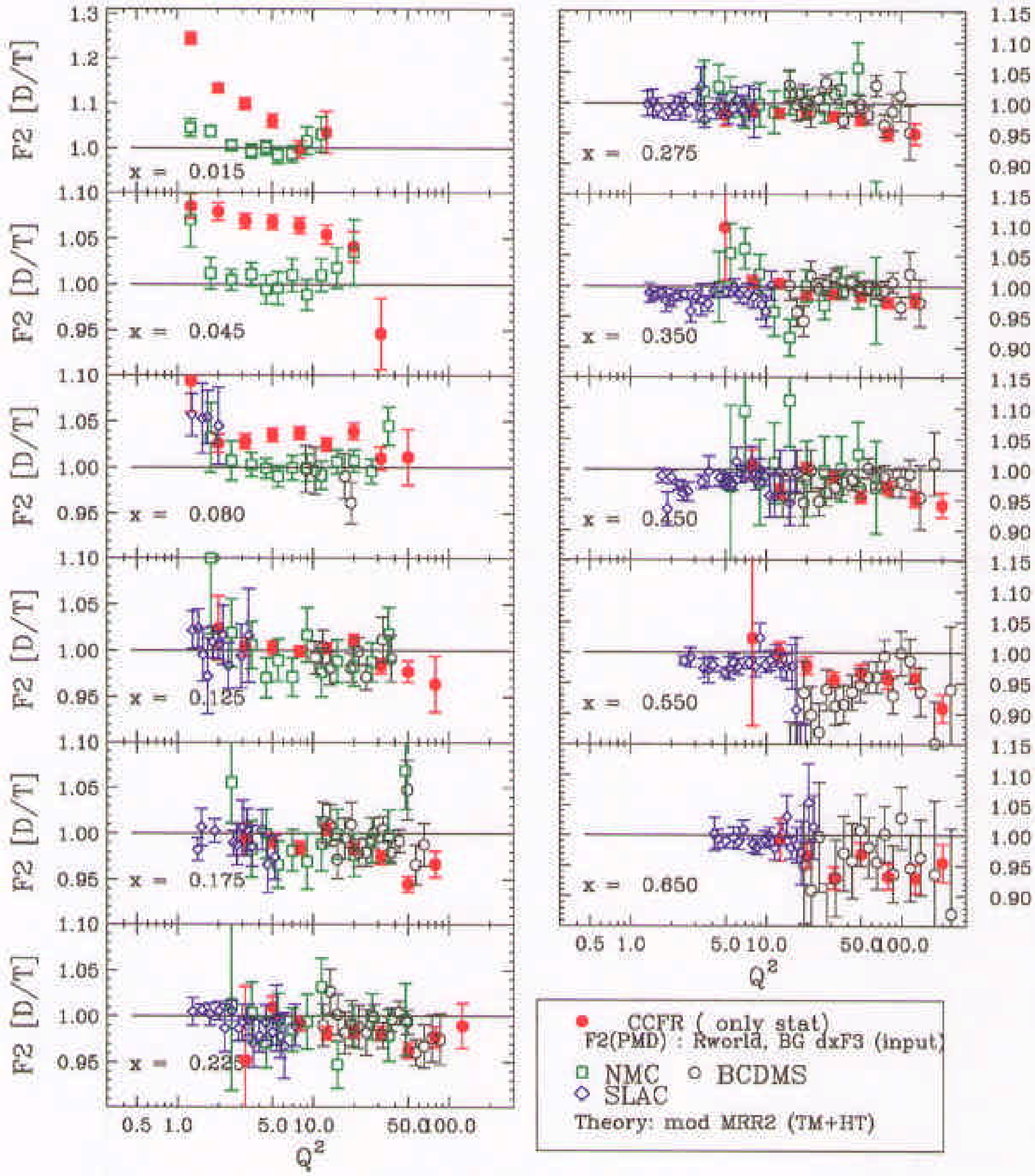
$y = E_{had} / E_k$
(inelasticity)

$$\frac{1}{E}\frac{d^2\sigma}{dxdy} = \frac{G_F^2 M}{\pi}\left[2xF_1\frac{y^2}{2} \mp F_2(1-y) \pm xF_3(y - \frac{y^2}{2})\right]$$

$$2xF_1 = \Sigma x(q \mp \overline{q}) \quad \sim \sigma_T$$
$$F_2 = \Sigma x(q \mp \overline{q} \mp 2k) \quad \sim \sigma_T + \sigma_L$$
$$xF_3^{\nu(\overline{\nu})} = \Sigma x(q - \overline{q}) \pm 2x(s-c) \quad \sim \sigma_{RH} - \sigma_{LH}$$

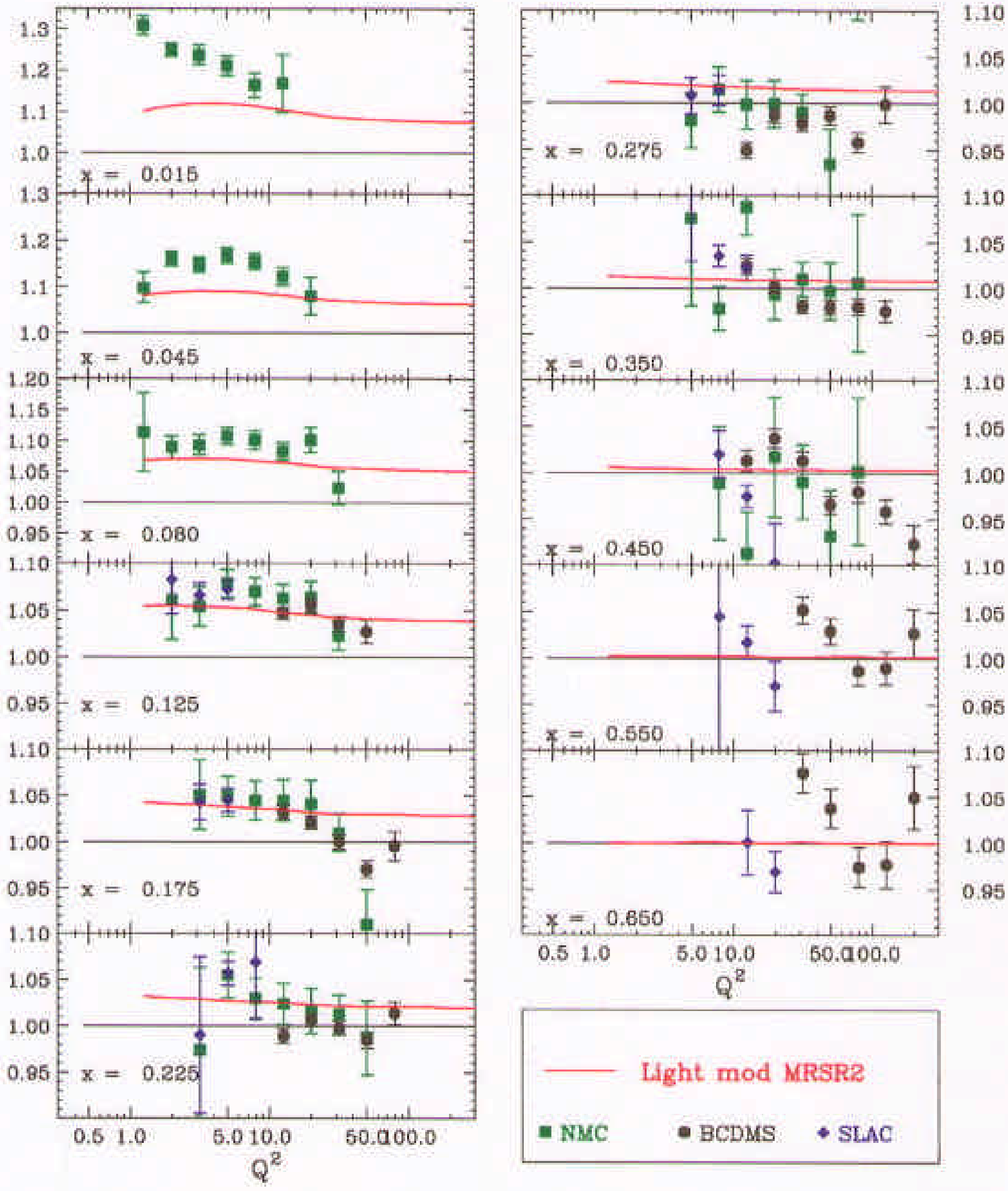
- ▷ F_2 & xF_3 (sea & valence quarks distributions)
- ▷ $R = \sigma_L/\sigma_T \sim (F_2 - 2xF_1)/2xF_1$
  (sensitive to gluon distribution at low x)
- ▷ xF_3^{ν}-$xF_3^{\overline{\nu}} = 4x(s-c) \equiv \Delta xF_3$
  (sensitive to the strange quark distribution)

Comparison of F_2^{μ} and F_2^{ν}(PMD:previous CCFR)



W. Seligman et al.,PRL 79, 1213(1997)

Comparison of F_2^{ν}(PMD:CCFR)/F_2^{μ} and theory



▷ $F_2^{\mu} = \frac{5}{18}F_2^{\nu} - \frac{1}{6}x(s + \overline{s} - c - \overline{c})$

Current issues relating to F_2

- F_2^ν & F_2^μ are well described by DGLAP, but there is a $10 \sim 20\%$ discrepancy at low region ($x < 0.1$) between F_2^ν(CCFR) and F_2^μ(NMC)

$\hookrightarrow F_2^\mu = \frac{5}{18} F_2^\nu - \frac{1}{6} x(s + \overline{s} - c - \overline{c})$

◁ The strange sea correction to $5/18 F_2^\nu$ is 10±2% at $x = 0.01$ (from fits to CCFR dimuon measurements)

◁ The nuclear correction to F_2(Fe) is 15±2% at $x = 0.01$ (from NMC/E665/SLAC[μ, e] measurements)

– Neutrino data are crucial in separating valence and sea quark distributions (xF_3 yields valence quarks)

♠ Several attempts to resolve this discrepancy

▷ Wrong strange sea at low x ?
(has to be increased by factor of two)

▷ $s(x) \neq \overline{s}(x)$? (need a negative $\overline{s}(x)$)

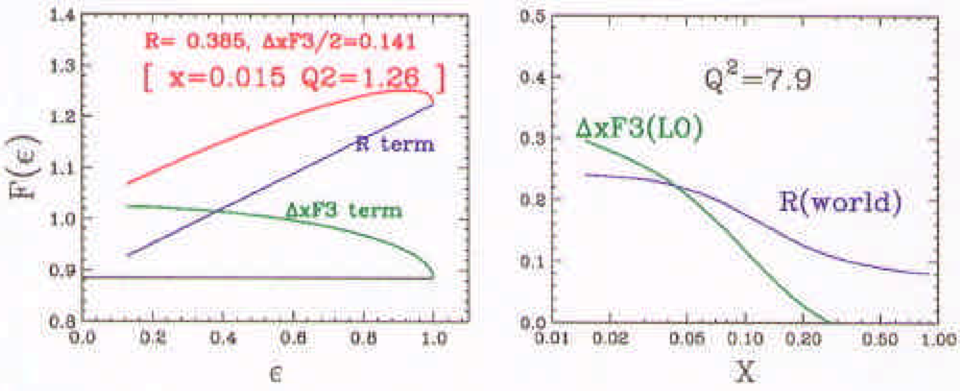
▷ Different nuclear effects ? Boros et al (only up to 5% difference)

▷ Charge symmetry violation? $\delta\overline{d} = \overline{d}^p - \overline{u}^n \neq 0$, $\delta\overline{u} \neq 0$.
(ruled out by Bodek et. al using CDF W asymmetry data)

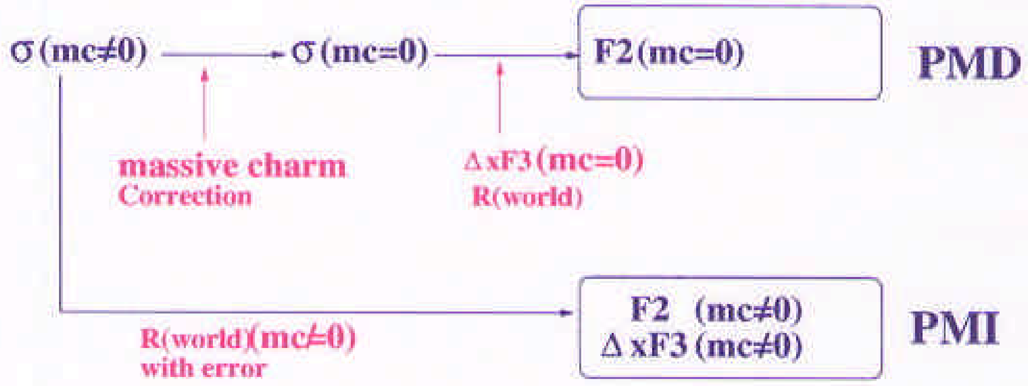
▷ Effects of massive charm used in the extraction procedure? (e.g. slow rescaling effects, $\Delta x F_3$ correction). We will show that a better procedure resolves the discrepancy

SFs extractions

$$F(\epsilon) \equiv \left[\frac{d^2\sigma^{\nu}}{dxdy} \mp \frac{d^2\sigma^{\overline{\nu}}}{dxdy}\right]\frac{(1-\varepsilon)\pi}{y^2G_F^2ME}$$
$$= 2xF_1(x,Q^2)[1 \mp \epsilon R(x,Q^2)] - \frac{y(1-y/2)}{1+(1-y)^2}\Delta xF_3(x,Q^2)$$



▷ Previous CCFR analysis: $F_2(m_c = 0)$ with $\Delta xF_3, R$ constraints, massive charm correction: PMD



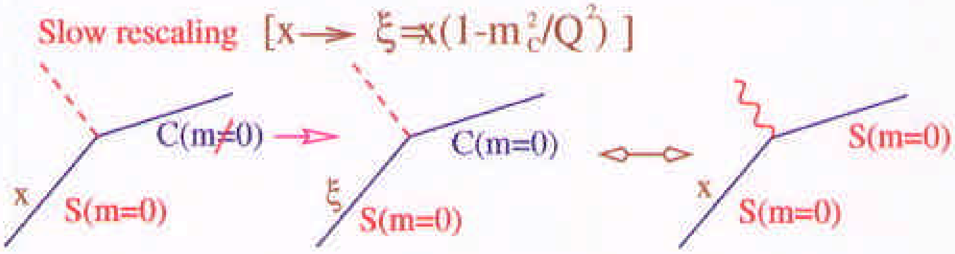
▷ New CCFR analysis: no massive charm correction

– $x < 0.1$: $F_2(m_c \neq 0), \Delta xF_3$ with R constraints: PMI

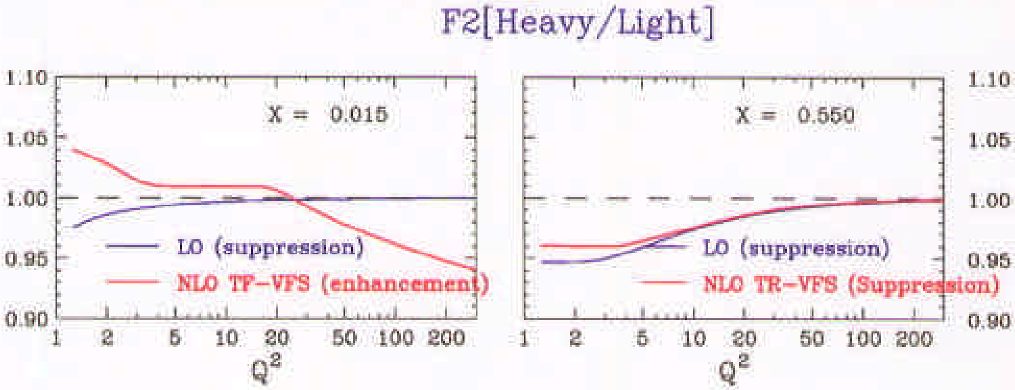
– $x > 0.1$: $F_2(m_c \neq 0)$ with $\Delta xF_3, R$ constraints

What makes us challenge?

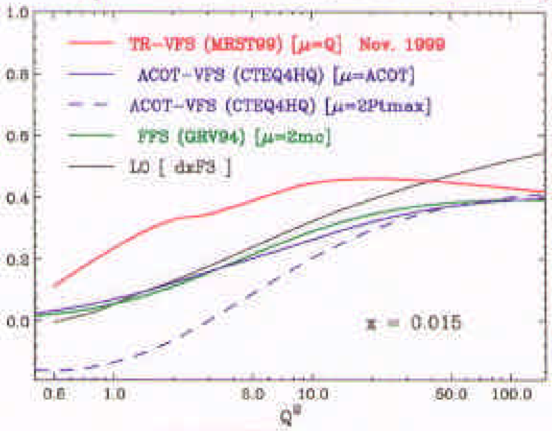
- Charm mass correction (based on CCFR LO)



◁ But NLO cal. shows an opposite behaviour at low x



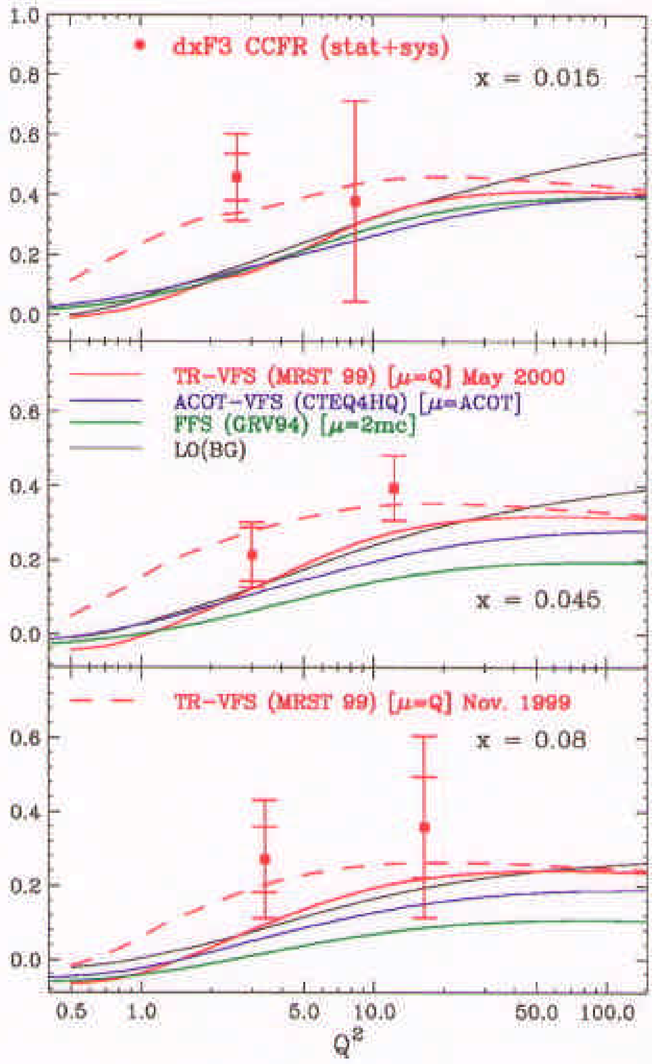
- ΔxF_3 correction (based on CCFR LO)



◁ How reliable are the NLO predictions for ΔxF_3 $(s(x))$?

▷ NO charm mass and ΔxF_3 corrections in the extraction

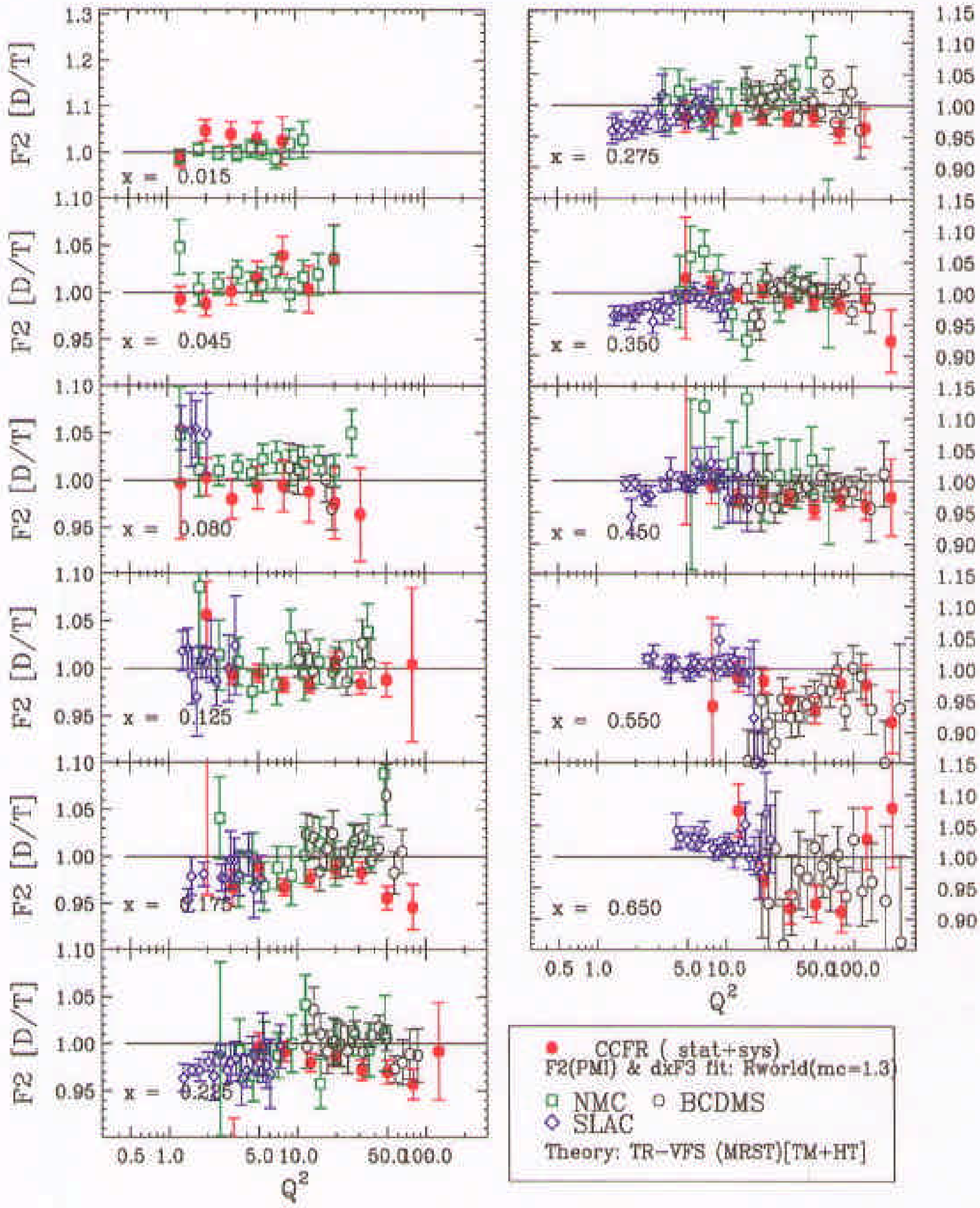
ΔxF_3 Results from the PMI analysis



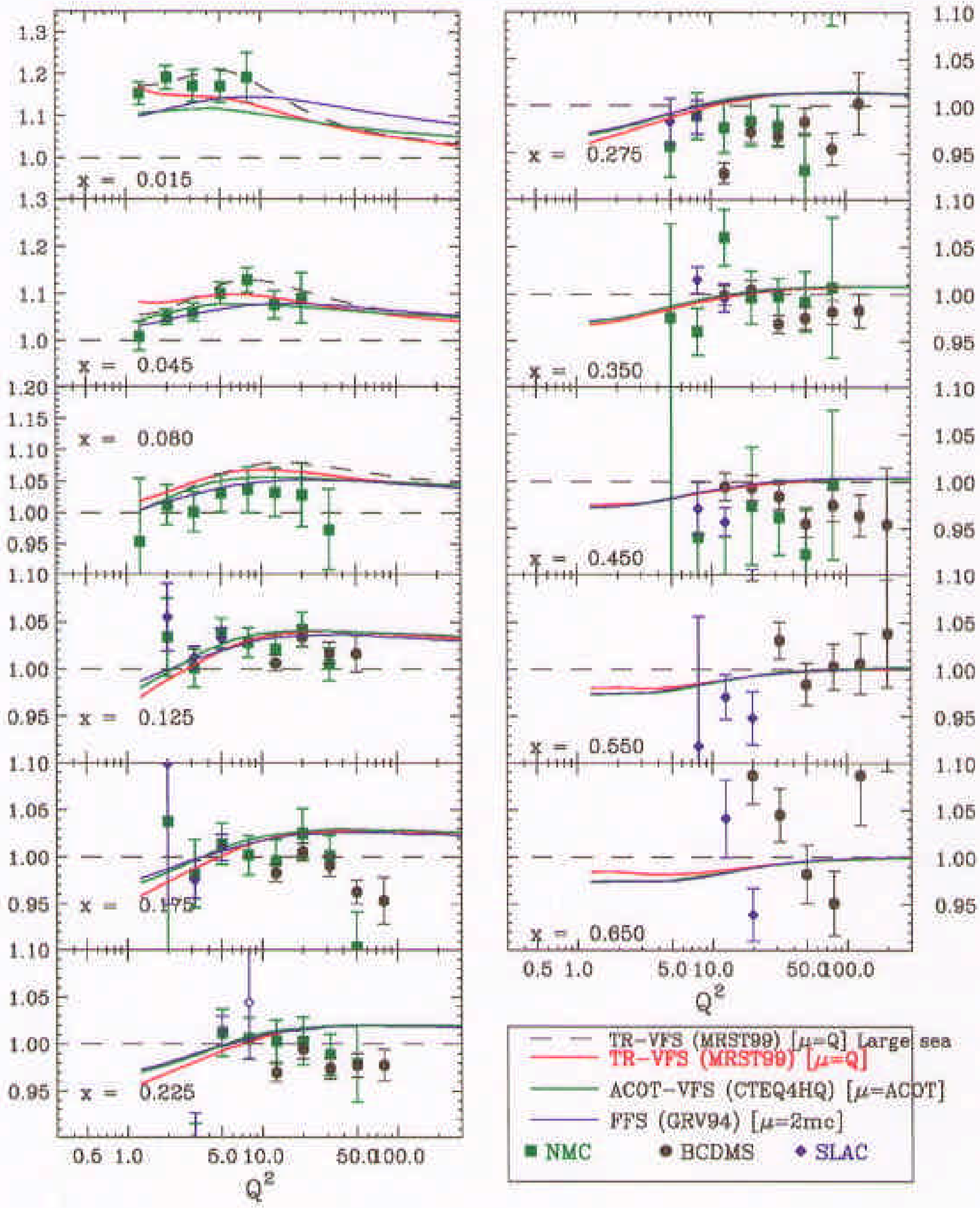
- Data appears higher than all LO or NLO models (is it missing NNLO terms at low Q^2, strange quark distribution (only measured with dimuons at high Q^2), or higher twist at low x and Q^2?)

♠ Note that the TR-VFS (MRST99) Nov. 1999 model code had a mistake (but it accidentally fits the data)

Comparison of F_2^{ν}(PMI:CCFR) and F_2^{μ}(muon)



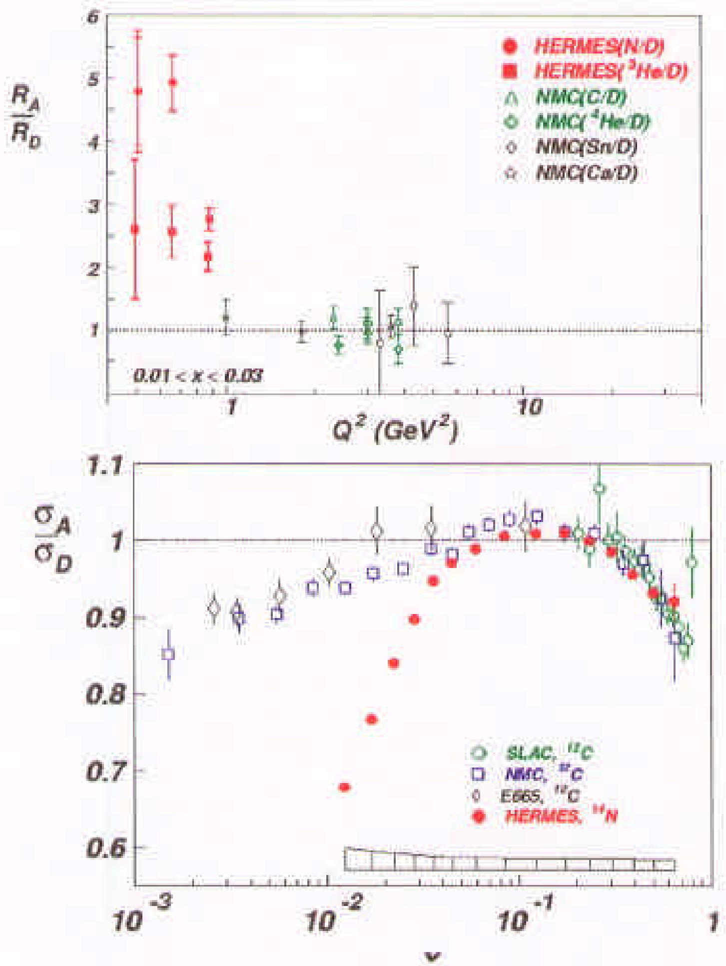
Comparison of F_2^{ν}(PMI:CCFR)/F_2^{μ} and theory



Current issues in R

▷ Primary interest: $R(x, Q^2)$ at low x

▷ HERMES shows a large nuclear effect in R?



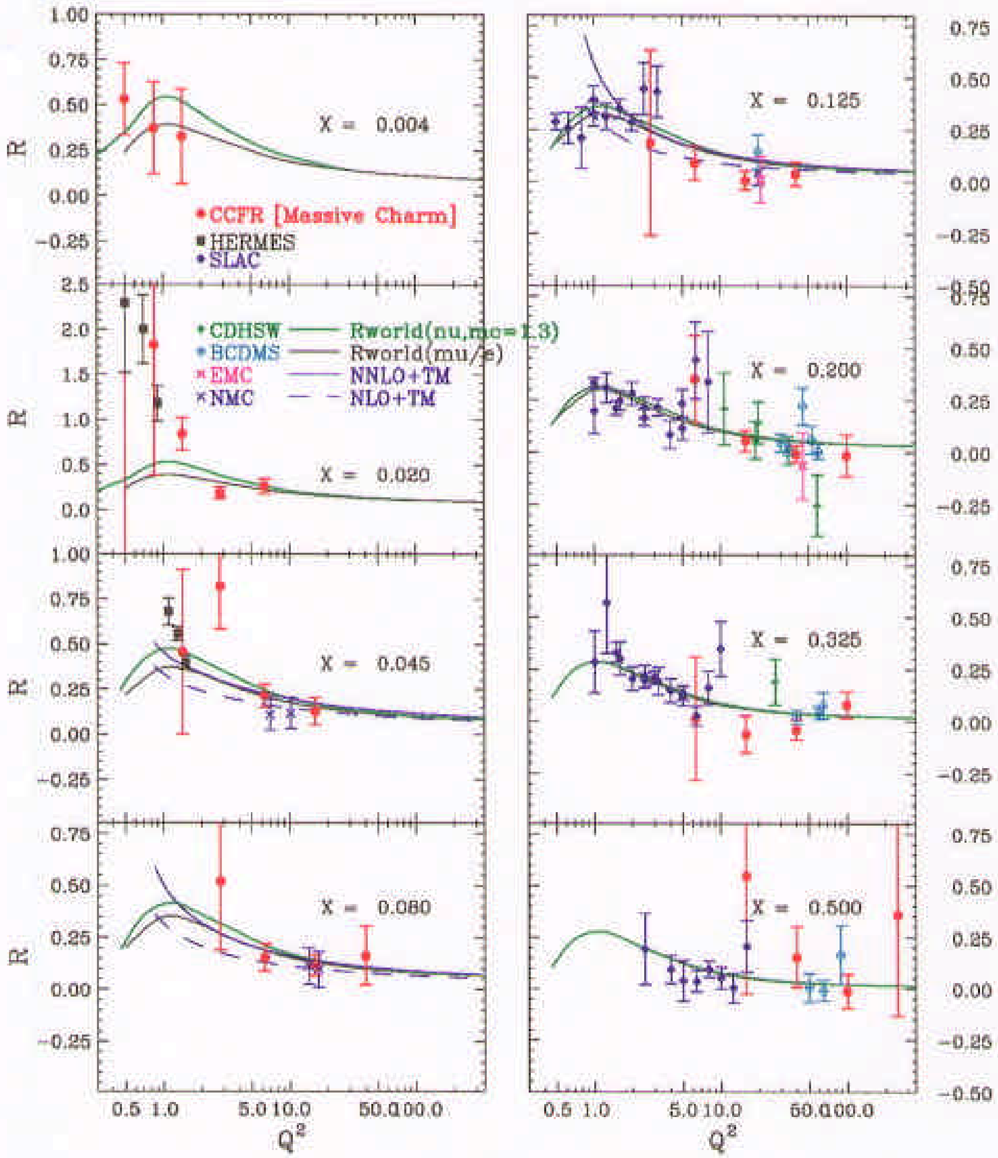
◁ NMC, E665 data
$Q^2 > 1$,
HERMES data
$Q^2 < 1$
at $0.01 < x < 0.1$

◁ $\frac{\sigma_A}{\sigma_D} = \frac{F_2^A(1+\epsilon R_A)(1+R_D)}{F_2^D(1+\epsilon R_D)(1+R_A)}$

◁ Q^2 dependence of F_2^A/F_2^D is weak, then R dependence?

- HERMES larger $R(= F_L/2xF_1)$ but same F_2
  ▷ implies enhancement in F_L but suppression in $2xF_1$ due to nuclear effects?

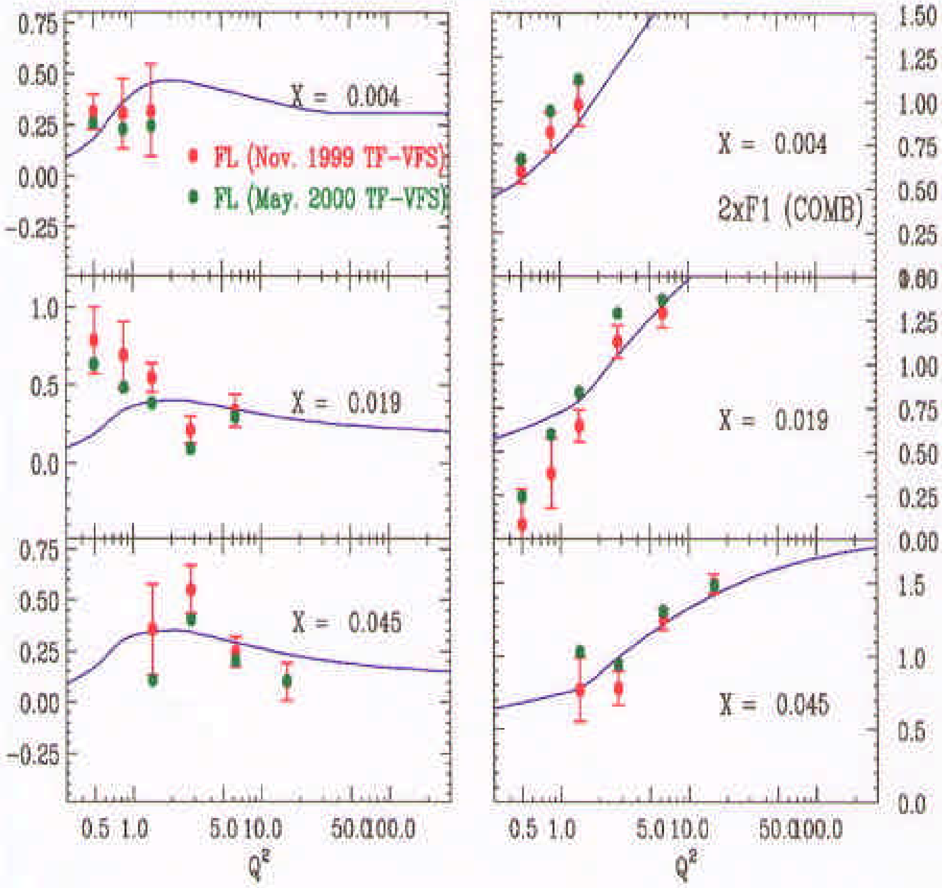
CCFR Results on R (Fe Target)



- The first measurement of the Q^2 dependence below $x = 0.1$ (Two nearest NMC points are shown together) Rworld and R (Bodek/Yang- QCD NNLO+TM) describe all data
- What about the HERMES effect?

Looking for the HERMES effect in CCFR R

Preliminary



◁ F_L and $2xF_1$ curves are constructed using CCFR F_2 and $R_{world}(m_c = 1.3)$ (i.e. no HERMES effect)

⇒ Interesting fluctuation at $x = 0.019$ but no anomalous effect is observed at $x = 0.004$

Conclusion and Future Prospects

1. The first measurement of ΔxF_3 (CCFR)
   - ▷ Data are higher than the LO, VFS-CTEQ4HQ, TR-VFS-MRST99 (correctd in May 2000) and FFS-GRV94 model predictions. Therfore, use the measured value instead
     This mostly resolves the long standing F_2 discrepancy
   - ▷ provides another tool for investigating the strange sea and understanding heavy quark production at low x.
2. CCFR F_2^ν data
   - ▷ now in good agreement with muon F_2 data within 5%, if the extraction is done in a model independent way, and compared using NLO calculations with massive charm production.
   - ▷ imply that nuclear target effects in neutrino and muon scattering are the same. $\Rightarrow$ safely use all data to extract PDFs at low x (within NLO models with massive charm production)
3. CCFR R data
   - ▷ An interesting fluctuation at $x = 0.01$ looks like the HERMES large value of R at very low Q^2, but an even lower x bin does not show this effect
4. New NuTeV data (Sign Selected Beam allows to access very high y data) will be analyzed within a year