# Measurement of $\nu$-N Differential cross-sections and Structure functions using the CHORUS lead calorimeter at CERN

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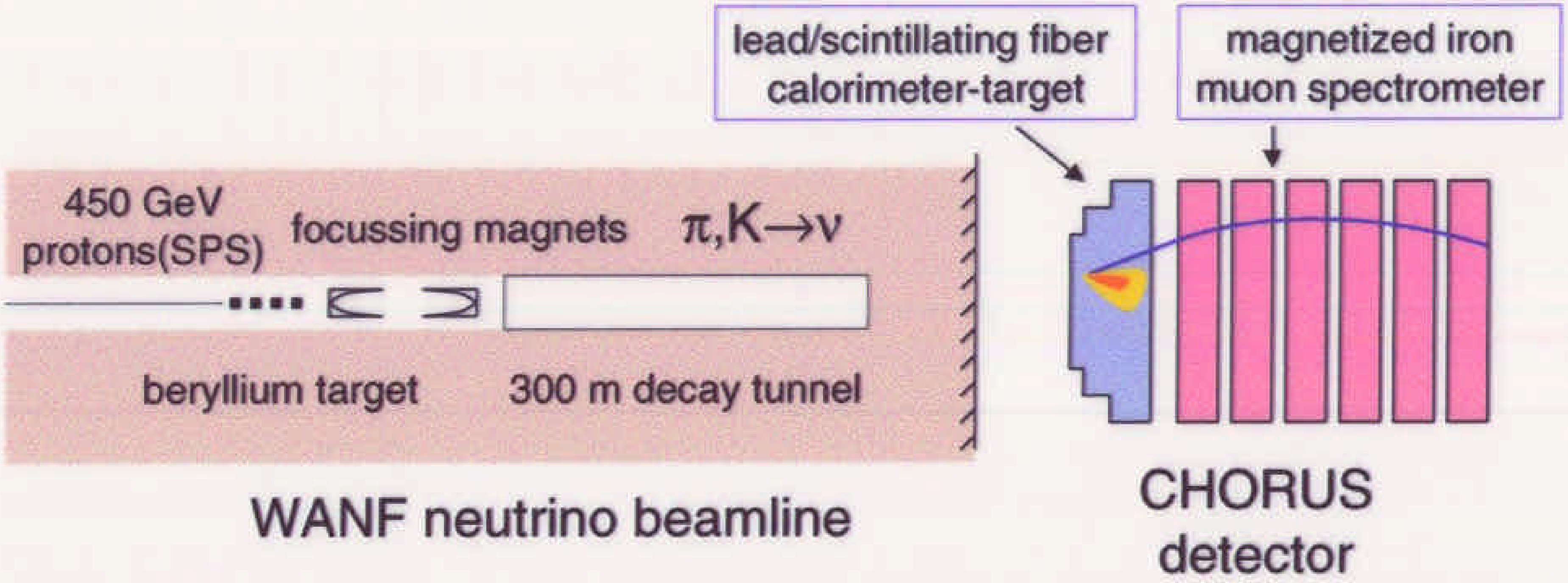
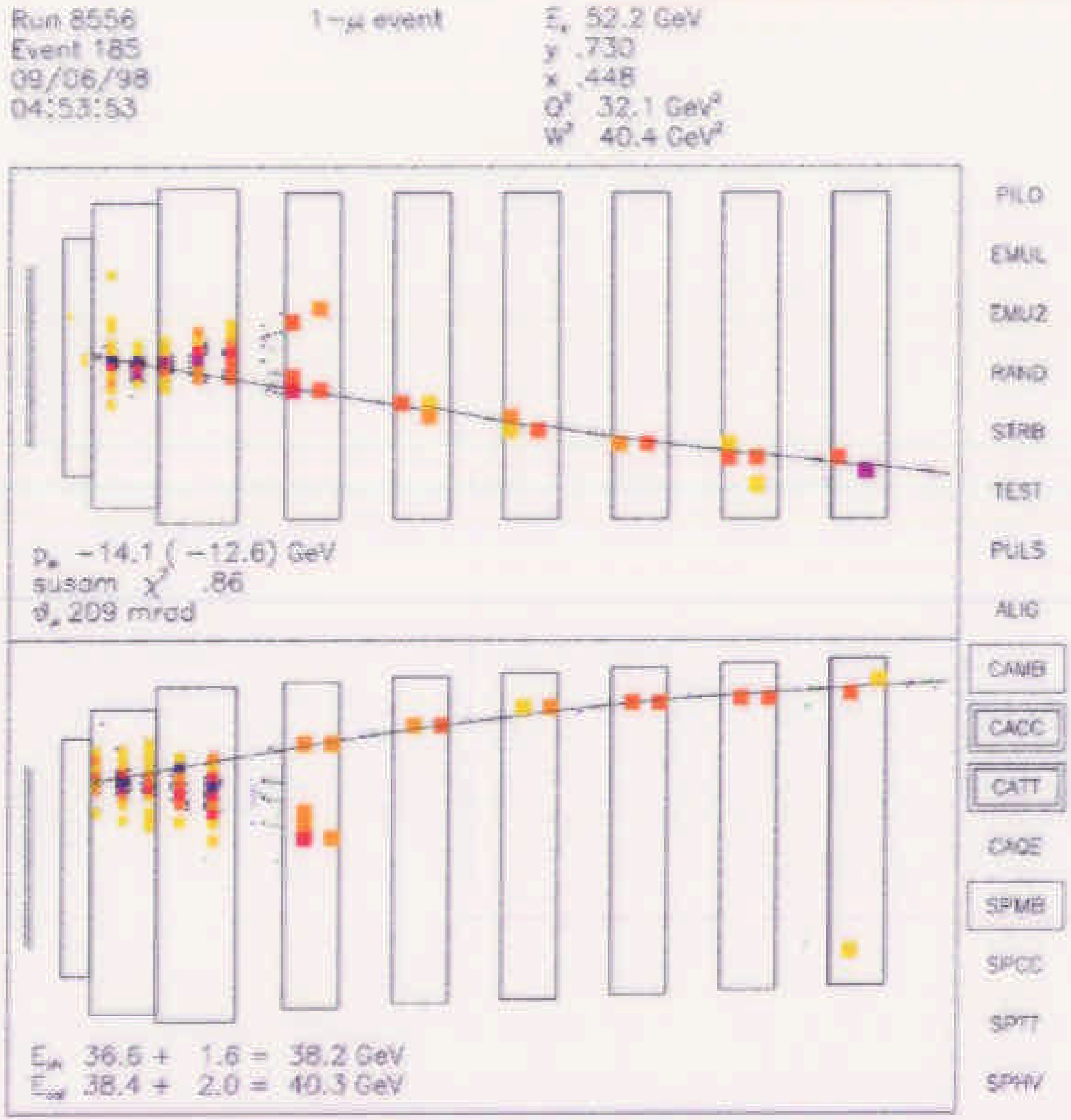
*for the CHORUS collaboration*

# Experimental setup



# A typical event




## Detector resolution:

$$\frac{\sigma(p_\mu)}{p_\mu} = 12-17\ \%$$

$$\sigma(\theta_\mu) = \frac{160-220}{p_\mu}\ \mathrm{mrad}$$

$$\sigma(E_{had}) = \frac{40-60\ \%}{\sqrt{E_{had}}}$$

## Kinematic variables:

$$E_\nu = p_\mu + E_{had}$$

$$y = E_{had} / E_\nu$$

$$Q^2 = 4E_\nu p_\mu \sin^2\left(\tfrac{1}{2}\theta_\mu\right)$$

$$x_{Bj} = \frac{Q^2}{2M_N E_{had}}$$

# CHORUS 1998 DIS data

| | $\nu$ beam | $\bar{\nu}$ beam |
|---|---|---|
| Triggered & selected: | 3638k | 1032k |
| After cuts: | 1125k | 234k |

Applied cuts:

- fiducial volume: 15.1 ton
- right sign muon (contamination:2%, 32%)
- $p_\mu > 4$ GeV
- $\theta_\mu < 300$ mrad
- $E_{had} < 100$ GeV
- $10 < E_\nu < 200$ GeV

# Differential ν-N cross-sections

| | | |
|---|---|---|
| binning in ($E_\nu$,x,y): | $10<E_\nu<200$GeV | 10 bins |
| | $0.01<x<0.7$ | 11 bins |
| | $0.05<y<0.95$ | 9 bins |

use:

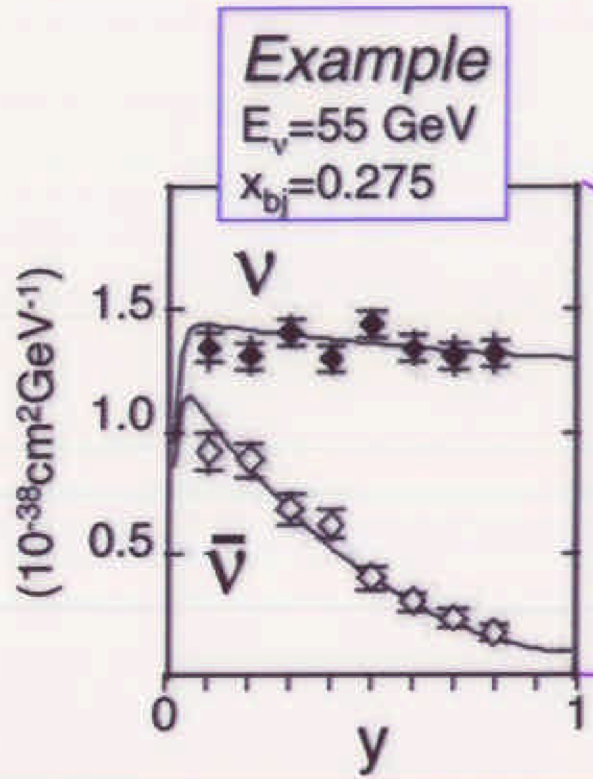
$$\frac{1}{E_\nu}\frac{d^2\sigma}{dxdy}=\frac{\sigma_{tot}^{\nu,\bar{\nu}}}{E_\nu}\frac{N(E_\nu,x,y)}{N(E_\nu)\Delta x\Delta y}$$

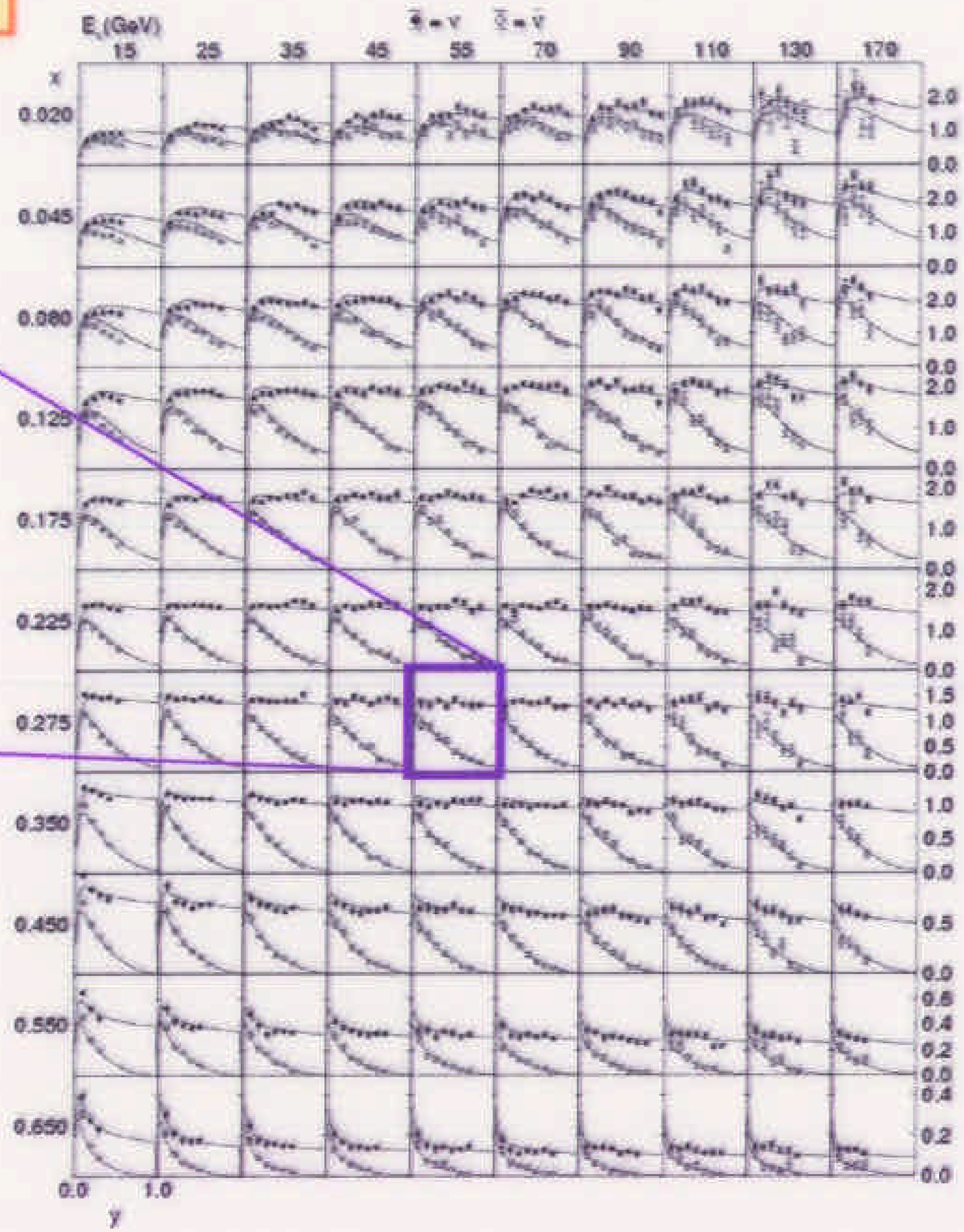
systematic uncertainties:

| | | | |
|---|---|---|---|
| $E_{had}$ scale | 5% ← Dominant! | total $\sigma^{\nu N}$ | 2.1% |
| $E_{had}$ offset | 150 MeV | total $\sigma^{\bar{\nu}N}/\sigma^{\nu N}$ | 1.4% |
| $p_\mu$ scale | 2.5% | $\sigma^{\nu N}(E)$ | 1%/100GeV |
| $p_\mu$ offset | 150 MeV | $\sigma^{\bar{\nu}N}/\sigma^{\nu N}(E)$ | 0.5%/100GeV |

# cross-section results





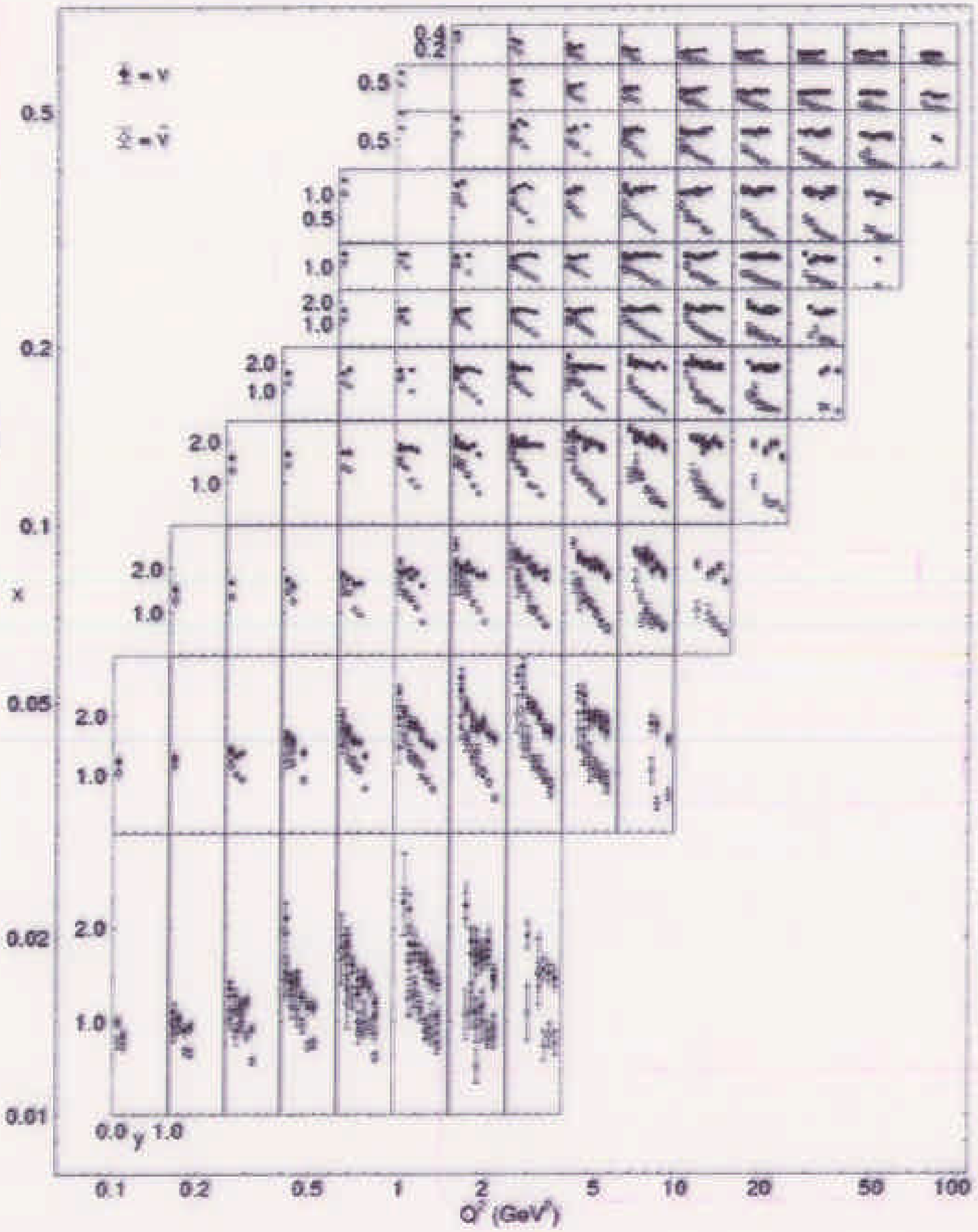




**First high statistics νN data on a lead target!**

*Numerical tables at*
`choruswww.cern.ch/~oldeman`

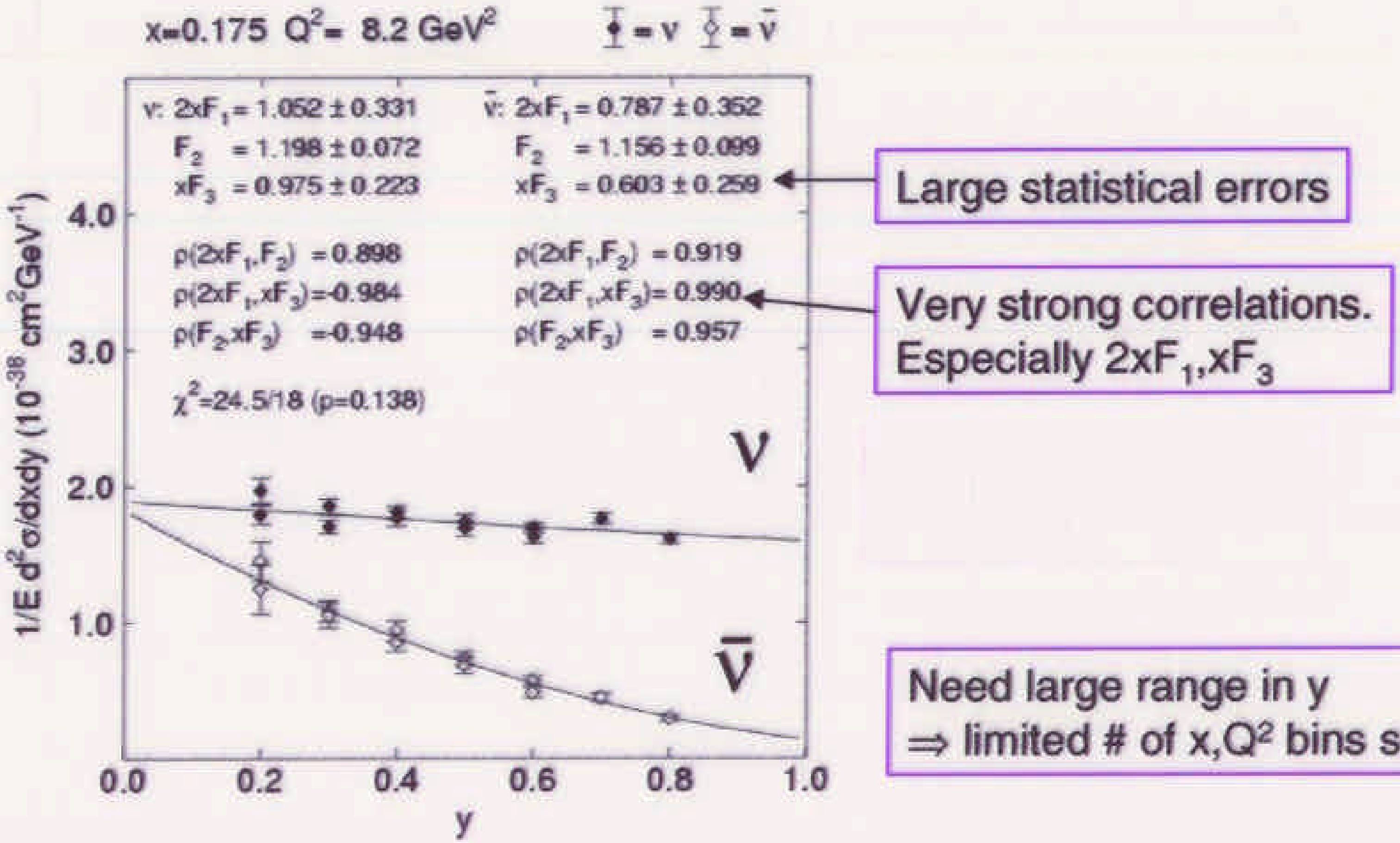
# Structure function extraction

- Binning E,x,y to $x, Q^2, y$
- Isoscalarity correction
- Radiative corrections (Bardin)



# Extracting 6 structure functions

$$\frac{d^2\sigma}{dxdy} = \frac{G_F^2 M_N E_\nu}{\pi\left(1+Q^2/M_W^2\right)^2}\left[\frac{1}{2}y^2\cdot 2xF_1 + \left(1-y-\frac{M_N xy}{2E_\nu}\right)F_2 \pm \left(y-\frac{1}{2}y^2\right)xF_3\right]$$

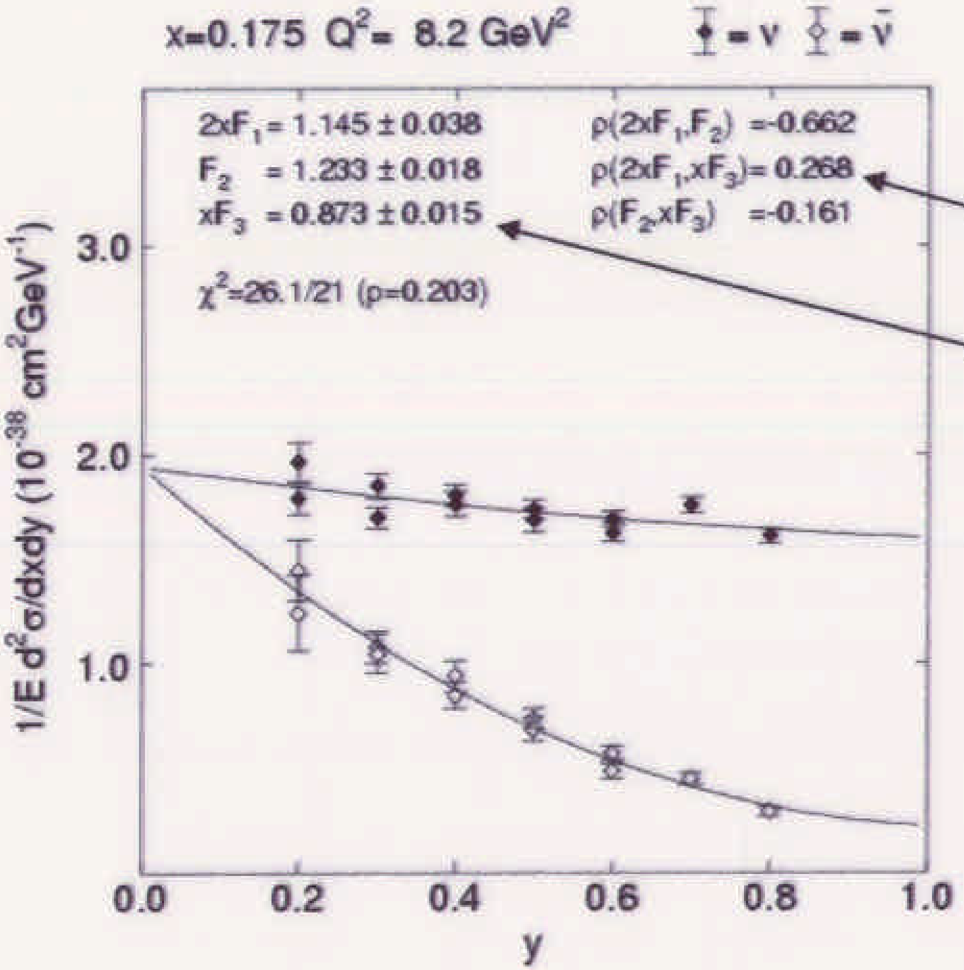



Need large range in y
⇒ limited # of x,$Q^2$ bins satisfy

# Extracting 3 structure functions

Assume:

$$2xF_1^{\nu} = 2xF_1^{\bar{\nu}}$$
$$F_2^{\nu} = F_2^{\bar{\nu}}$$
$$xF_3^{\nu} - xF_3^{\bar{\nu}} = 4(s-c)$$



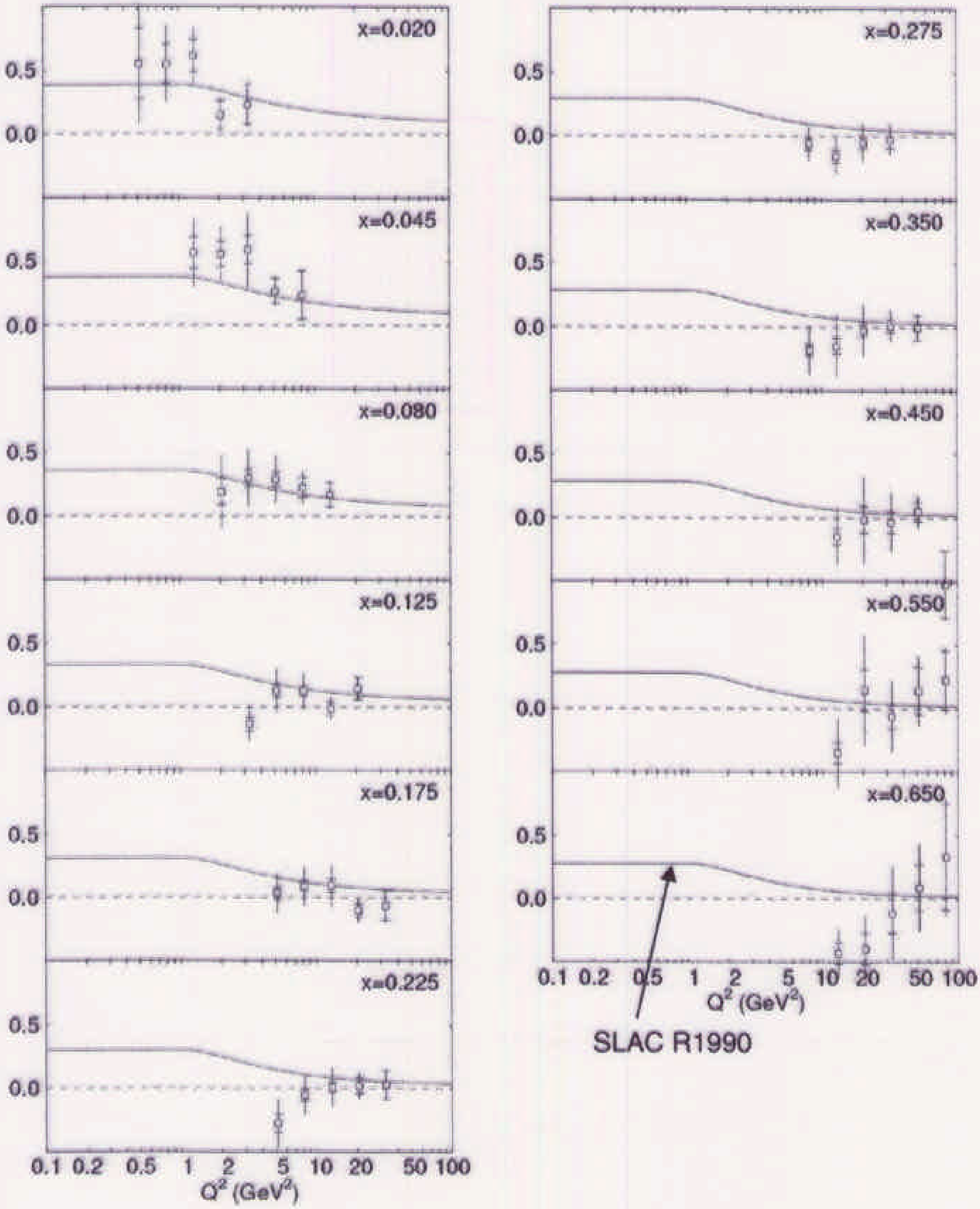

Reasonable correlations

10x smaller statistical error

⇒ measure $R(x,Q^2)$:

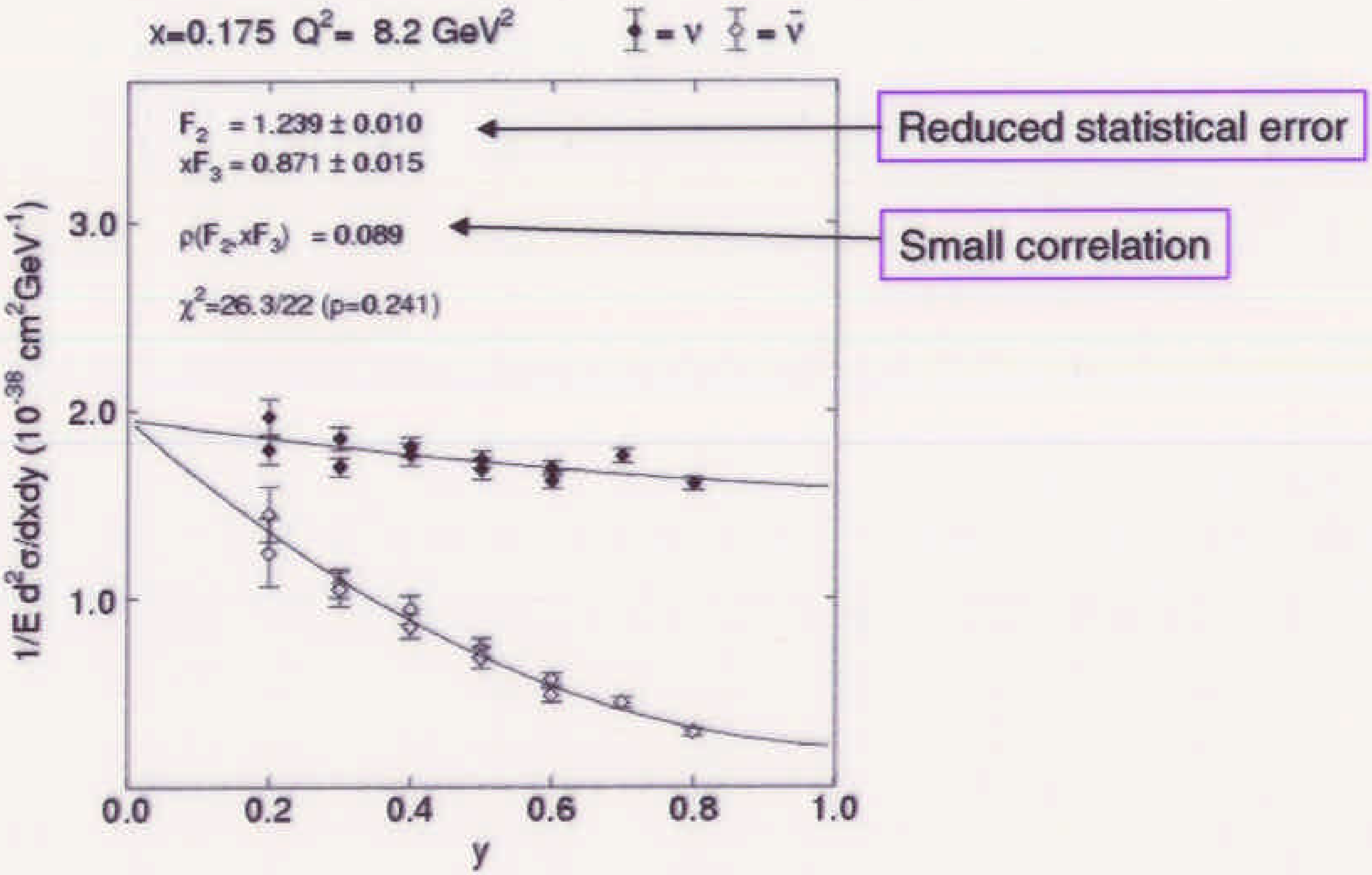
$$R = \left(1 + \frac{4M_N^2 x^2}{Q^2}\right)\frac{F_2}{2xF_1} - 1$$

# Results on $R(x,Q^2)$

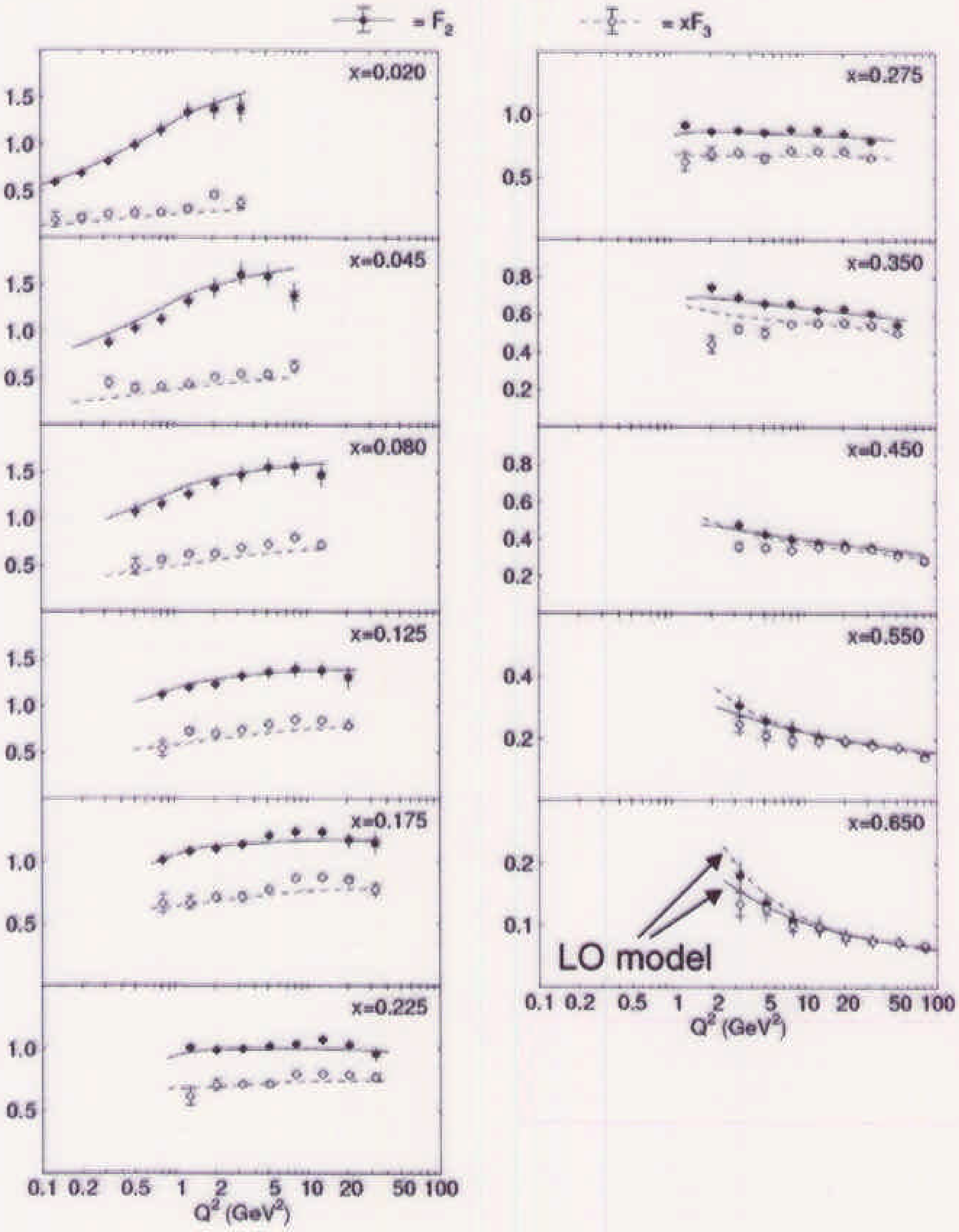


# 'Classical' 2-structure function extraction

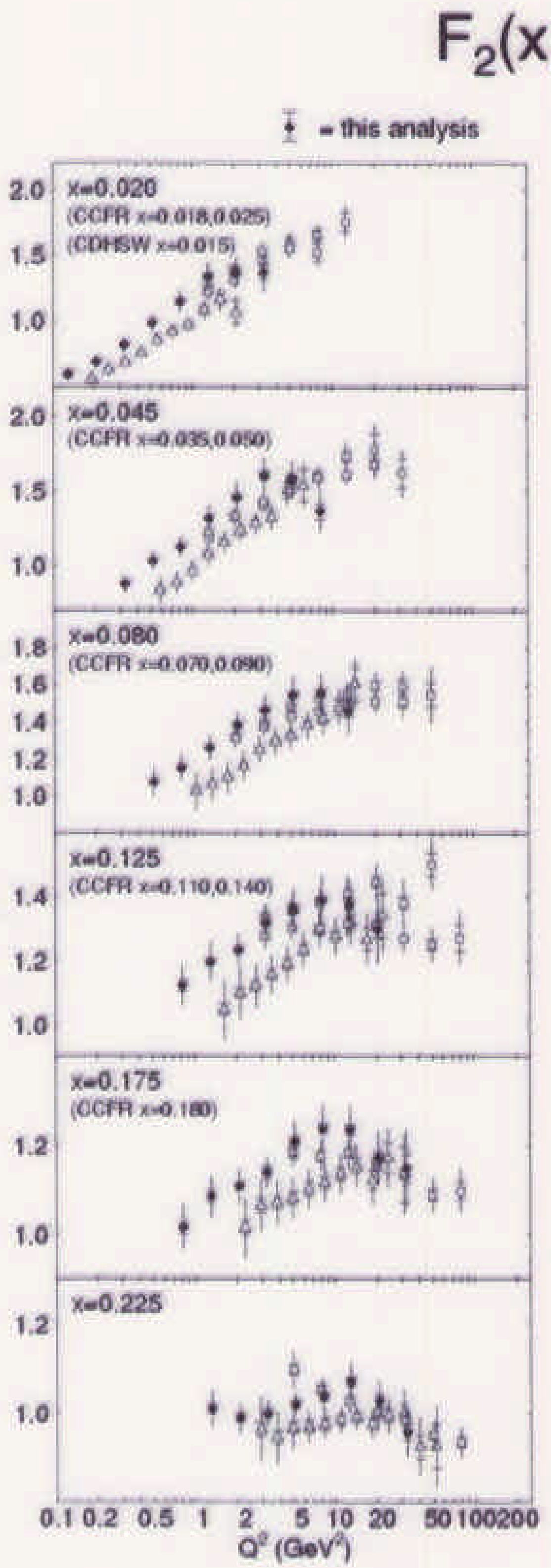
Use $R(x,Q^2)$ = SLAC R1990 (±20%)



# Measured structure functions $F_2(x,Q^2)$ and $xF_3(x,Q^2)$

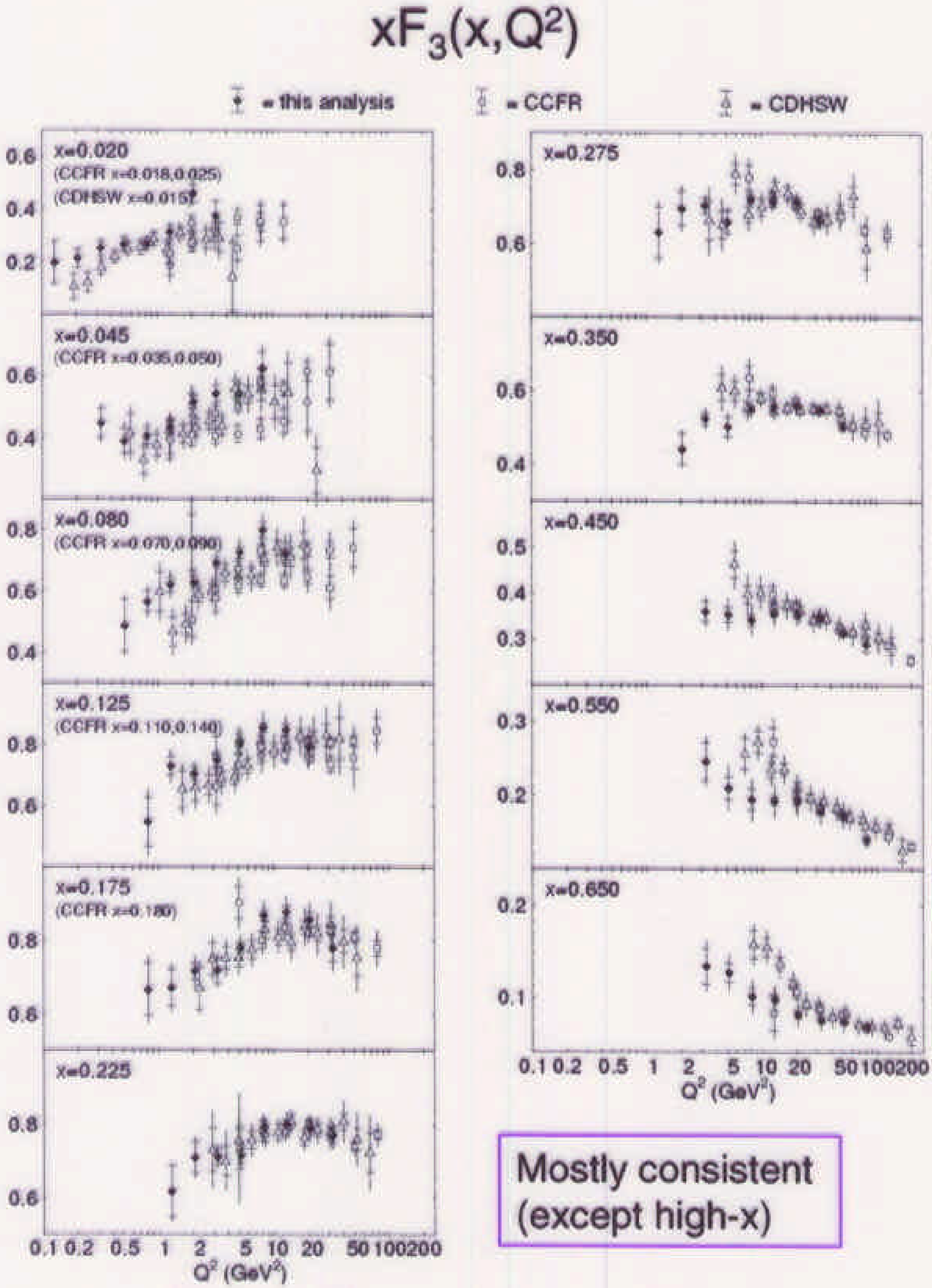


# Comparison with CCFR and CDHSW




Consistent with CCFR
Inconsistent with CDHSW

# Comparison with CCFR and CDHSW




Mostly consistent
(except high-x)

# Conclusions

- First high statistics neutrino data on a lead target
- Differential cross-section measured
- Structure functions $F_2(x,Q^2)$, $xF_3(x,Q^2)$ and $R(x,Q^2)$ measured
- Consistent with CCFR, discrepancy with CDHSW