MRS

MRS

+ T

James left his prestigious CERN Staff Member job
and gained, against strong competition,
a faculty position at Durham in Sept. 1986

He joined a small, active, outward-looking particle thy group.
He stayed in Durham for 22 very successful years

He now taught u/grads, supervised post-grades
but his innovative research continued unabated:

--- continued research with colleagues at CERN and elsewhere
--- started new projects with colleagues at Durham

one of the first was MRS

m_t= 40, >23, <67 GeV ??

N_ν=3,4...

ON THE DETERMINATION OF LIMITS ON THE NUMBER OF LIGHT NEUTRINOS AND THE TOP QUARK MASS FROM W, Z PRODUCTION IN $p\bar{p}$ COLLISIONS

A.D. MARTIN [a], R.G. ROBERTS [b] and W.J. STIRLING [a]

MRS: January 1987

$$R = \frac{\#(W \to e\nu)}{\#(Z \to ee)} = \frac{\sigma_W}{\sigma_Z} \frac{BR(W \to e\nu)}{BR(Z \to ee)} \equiv R_\sigma \cdot R_{BR}$$

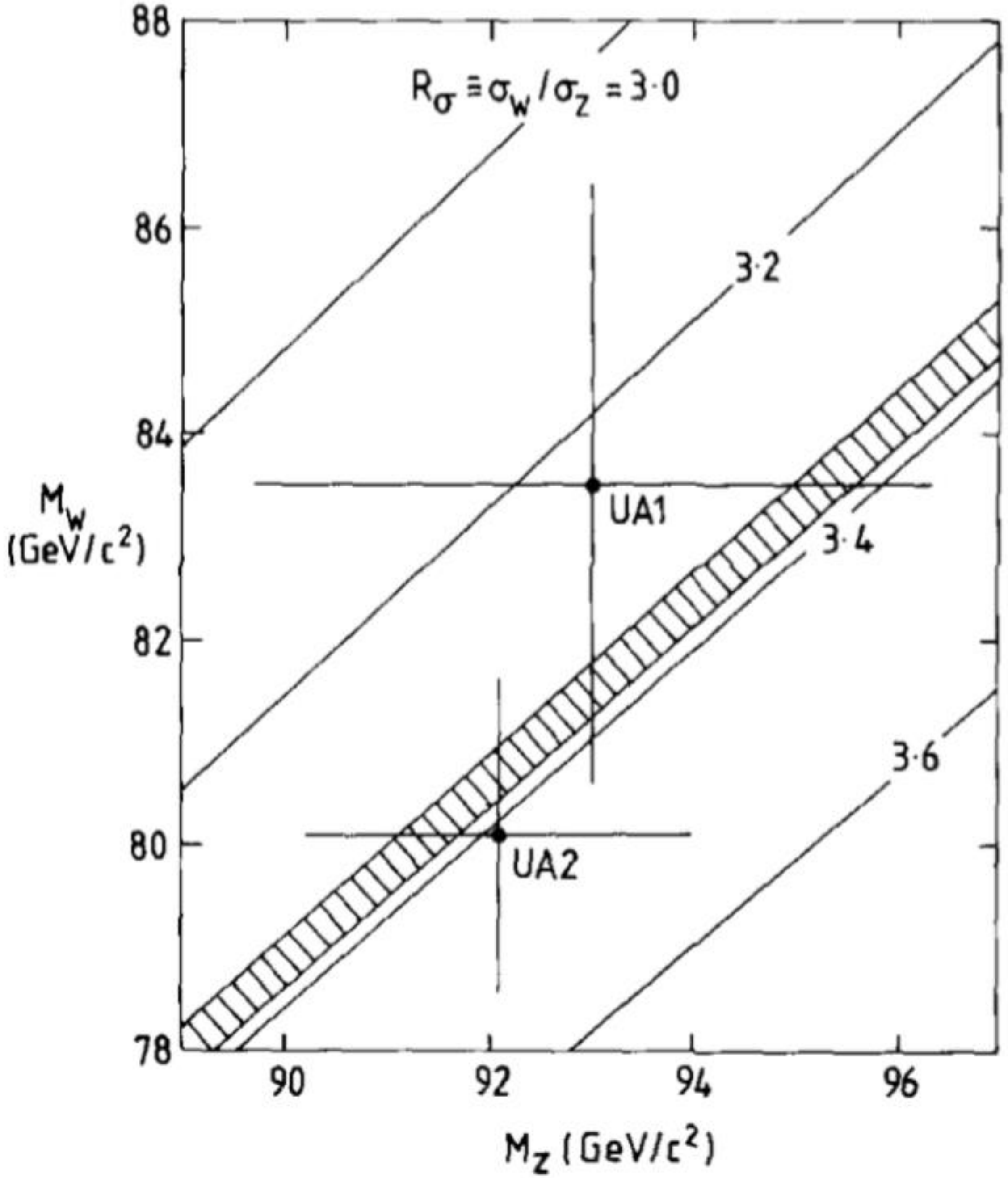
Main uncertainty due to use of existing LO PDF sets

MRS directly analysed p,d DIS data → NLO PDFs

F_2^n/F_2^p data crucial for u/d

N_ν<4.9, m_t not constrained

James' plots



Error on R_σ due to uncertainty on $\sin^2\theta_W$

R_σ = 3.36+/-0.09

Next step followed soon after (July 1987)

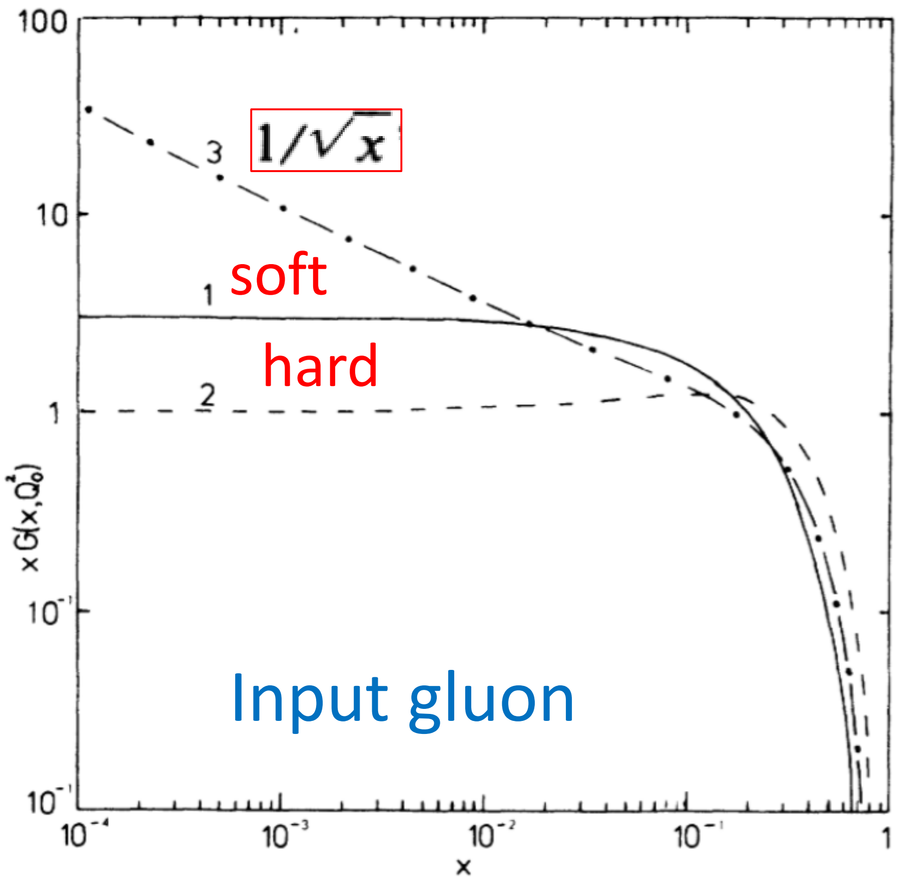
→ First ever NLO fit to global data

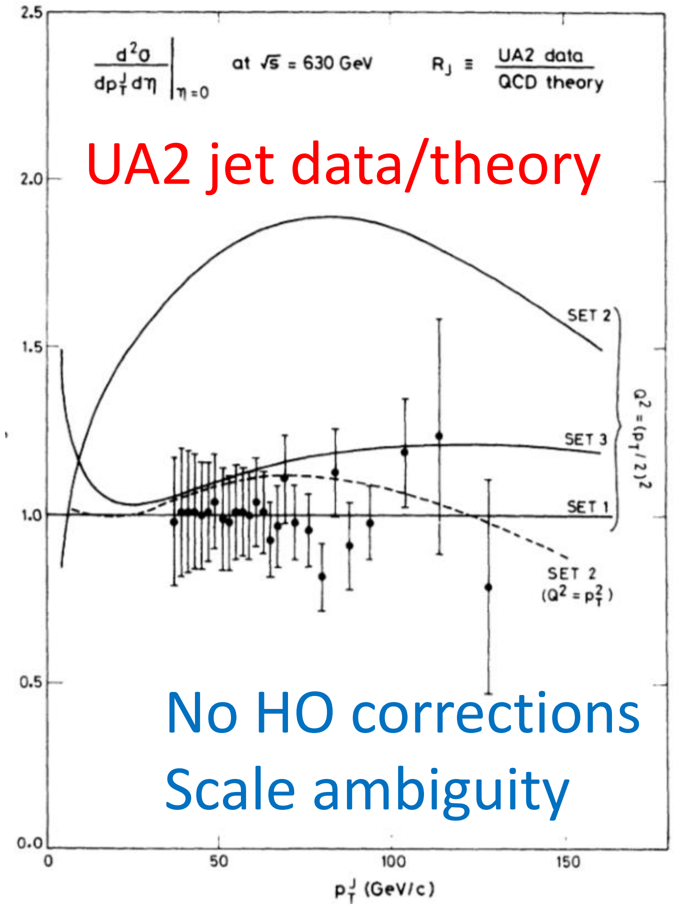
→ Towards the determination of the partonic structure of proton that is the PDFs of the proton

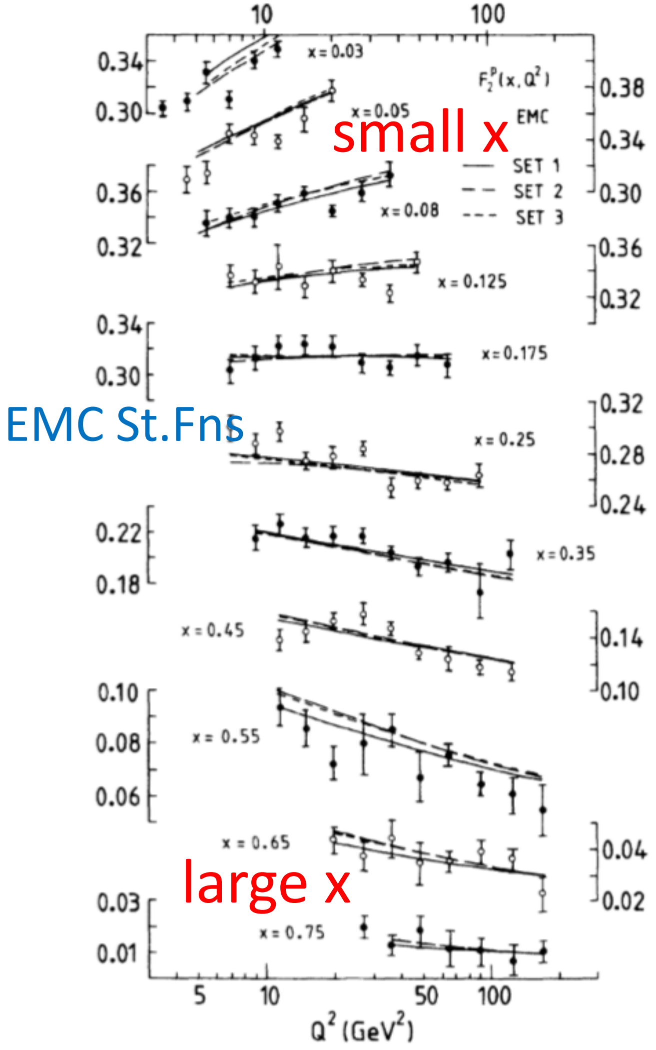
→ An activity which has become increasingly important to this day

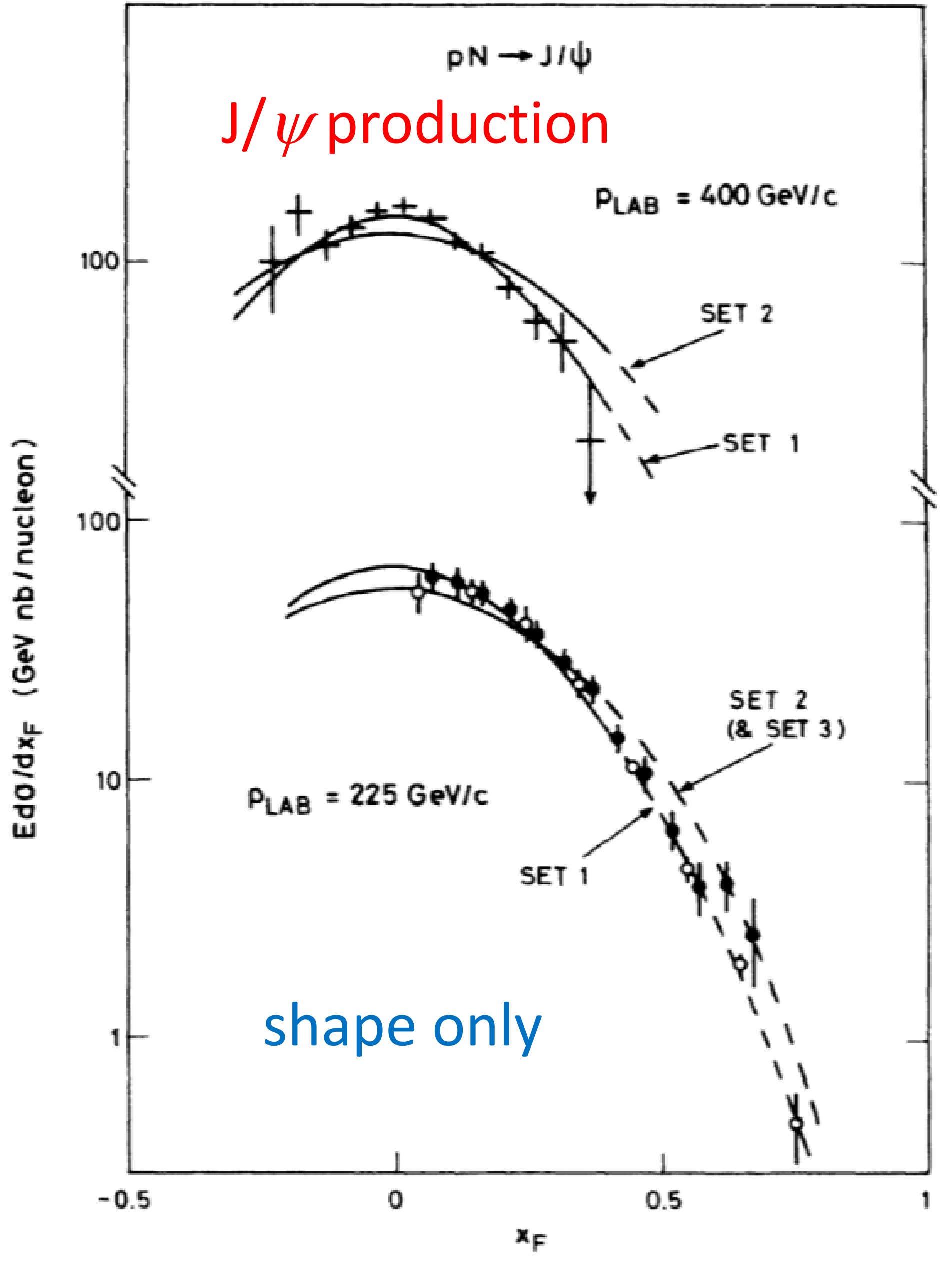
Structure-function analysis and ψ, jet, W, and Z production: Determining the gluon distribution

MRS July 1987

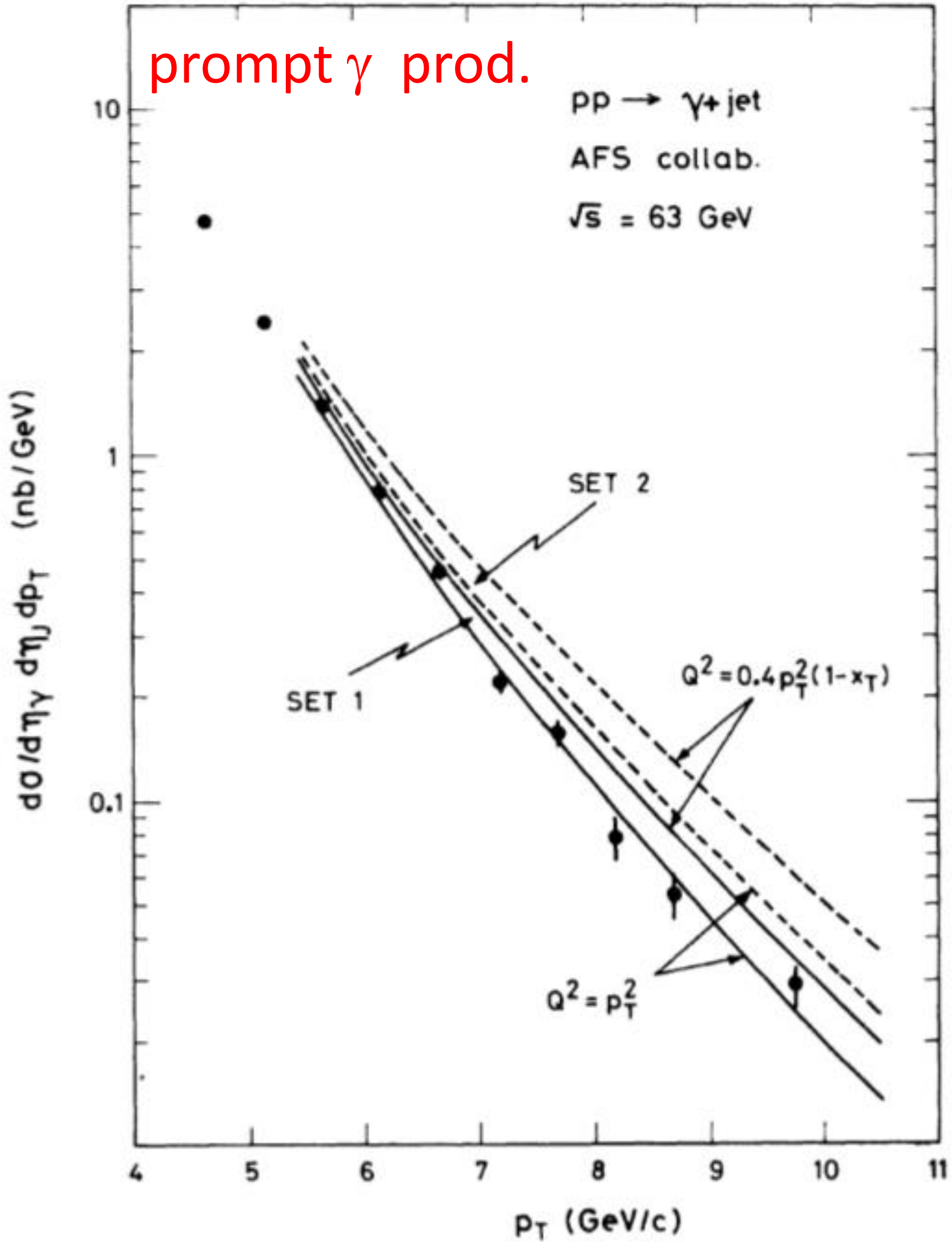








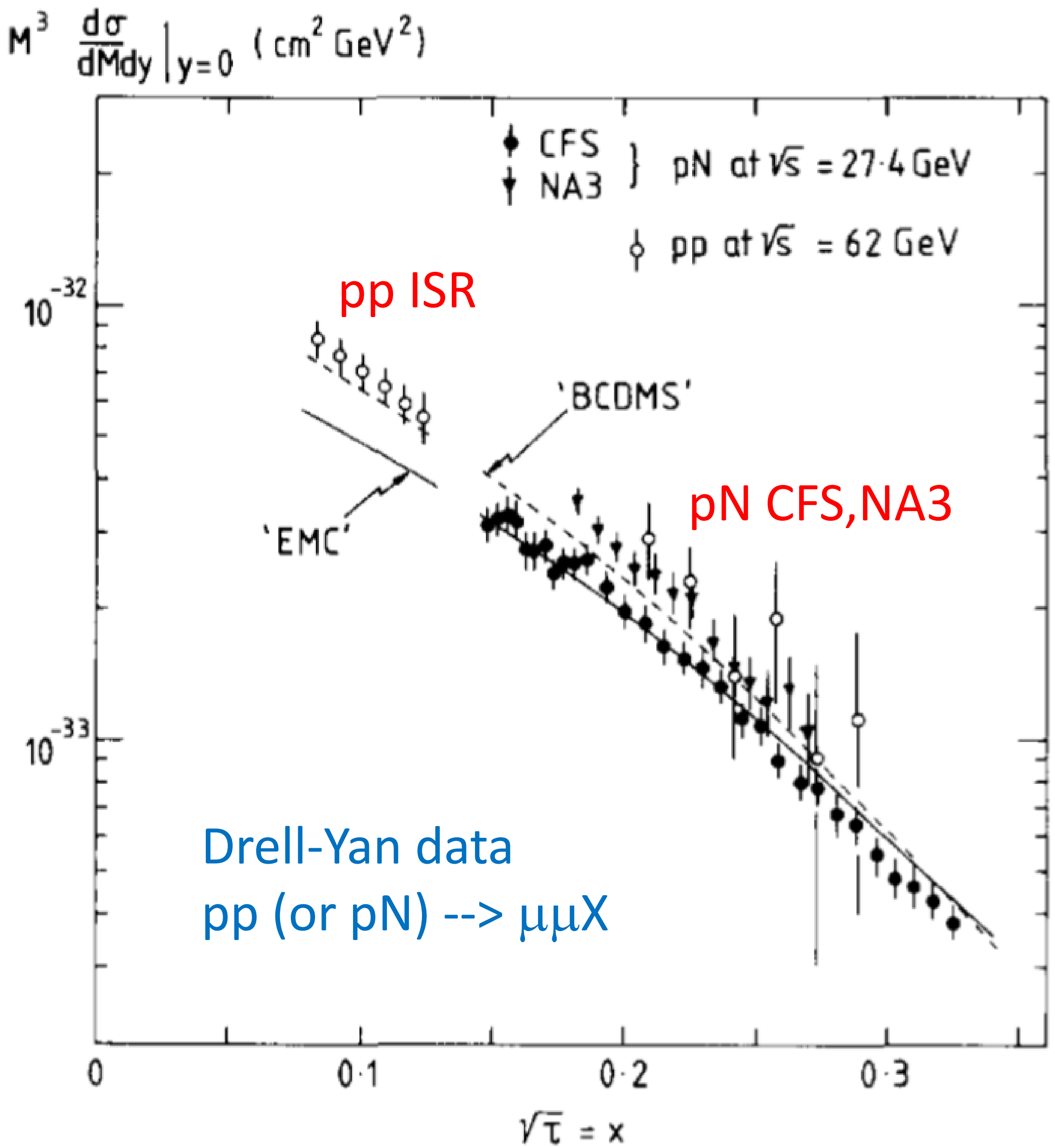
pN → J/ψ
J/ψ production
P_{LAB} = 400 GeV/c
SET 2
SET 1
100
100
10
1
P_{LAB} = 225 GeV/c
SET 2
(& SET 3)
SET 1
shape only
$Ed\sigma/dx_F$ (GeV nb/nucleon)
-0.5
0
0.5
1
x_F



prompt γ prod.
pp → γ+ jet
AFS collab.
$\sqrt{s}$ = 63 GeV
10
1
0.1
SET 2
SET 1
$Q^2 = 0.4 p_T^2 (1-x_T)$
$Q^2 = p_T^2$
$d\sigma/d\eta_\gamma\, d\eta_J\, dp_T$ (nb/GeV)
4
5
6
7
8
9
10
11
p_T (GeV/c)

Next MRS paper: Dec.1987

IMPLICATIONS OF NEW DIS DATA FOR PARTON DISTRIBUTIONS



Altho' equally good, but different fits to EMC, BCDMS μN data + νN data are possible,
Drell-Yan data favours BCDMS

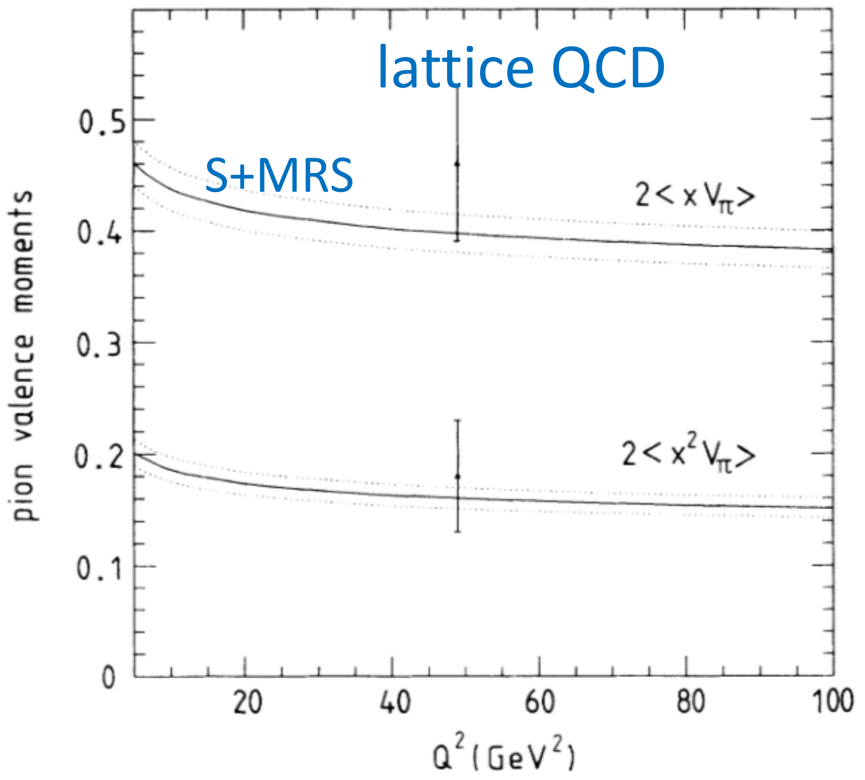
Another MRS innovation, now standard practice in PDF studies, was to give benchmark predictions for processes which may be observed in future collider experiments.

Benchmark cross sections for $p\bar{p}$ collisions at 1.8 TeV

August 1988

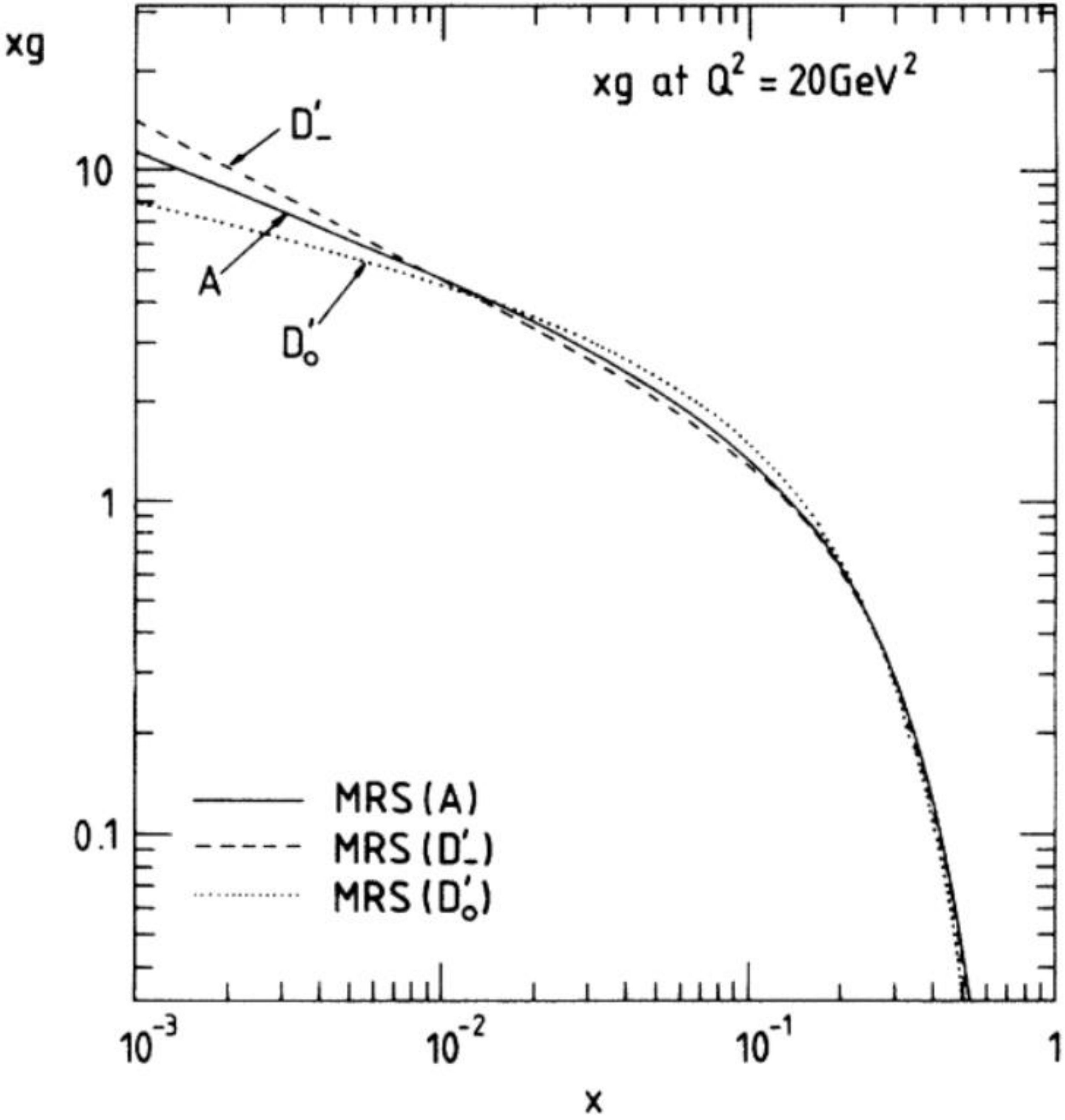
Kwiecinski +MRS performed an early study (1990) of PDFs at low x where the gluon dominates. This analysis went beyond the conventional (leading twist) formalism to include and quantify shadowing corrrections---and most importantly gave the effect of these corrections for other processes.

Sutton +MRS (1992) gave the first determination of the PDFs of the pion in a NLO "global" analysis of data from Drell-Yan and prompt photon experiments. Moments of q^{π}_{val} shown to agree with lattice QCD



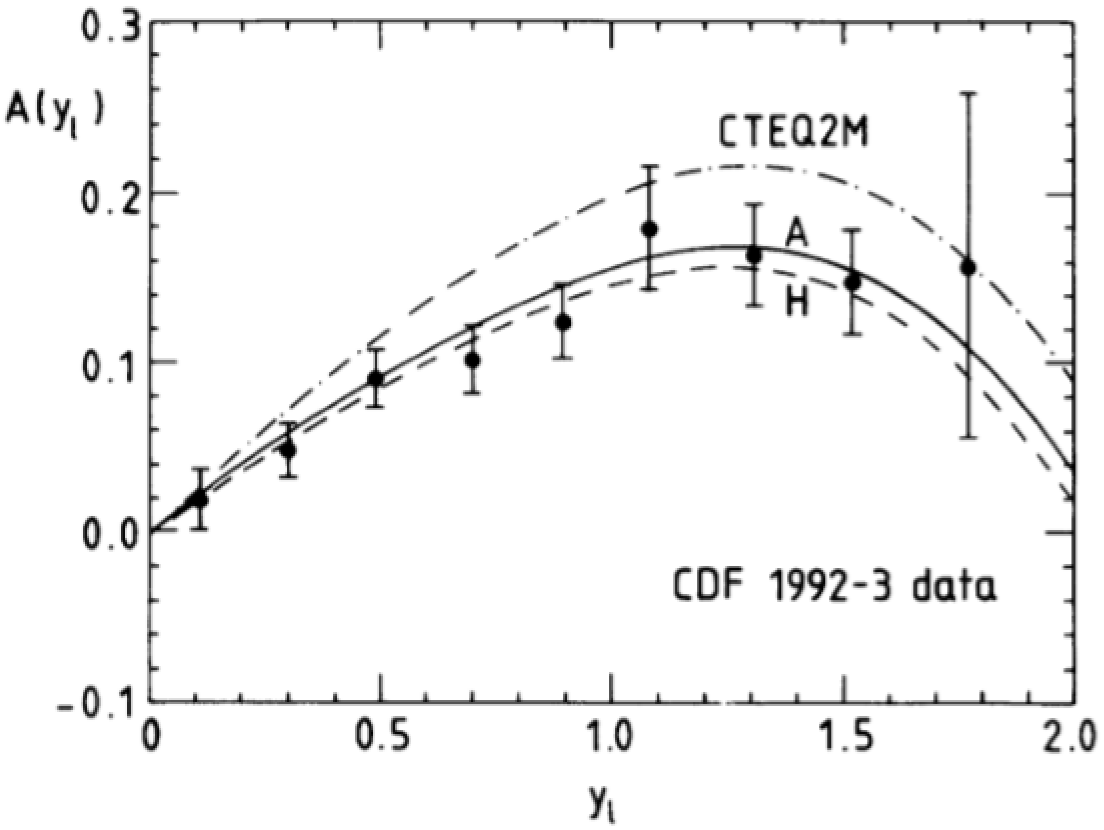
MRS were continually updating the (conventional) PDFs of the proton as new data became available.

Global fit in 1994 following advent of HERA DIS data, allows a better determination of the gluon PDF gluon with HERA data included in global fit



$W^{\pm} \to l^{\pm}\nu$ asymmetry in rapidity depends on slope of d/u

$$\boxed{A(y_l) = \frac{\sigma(l^+) - \sigma(l^-)}{\sigma(l^+) + \sigma(l^-)}}$$



pp, pn Drell-Yan asymmetry pins down $\bar{d} - \bar{u}$ (WJS+SE)

$$\boxed{A_{\mathrm{DY}} = \frac{\sigma_{pp} - \sigma_{pn}}{\sigma_{pp} + \sigma_{pn}}}$$

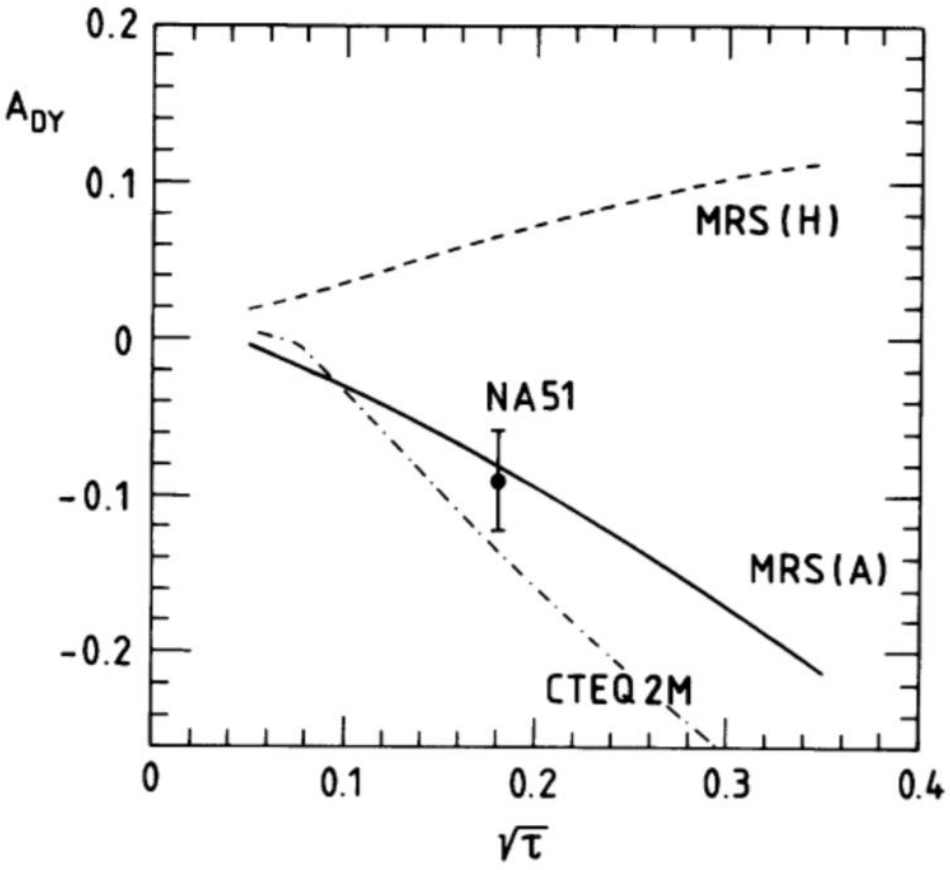
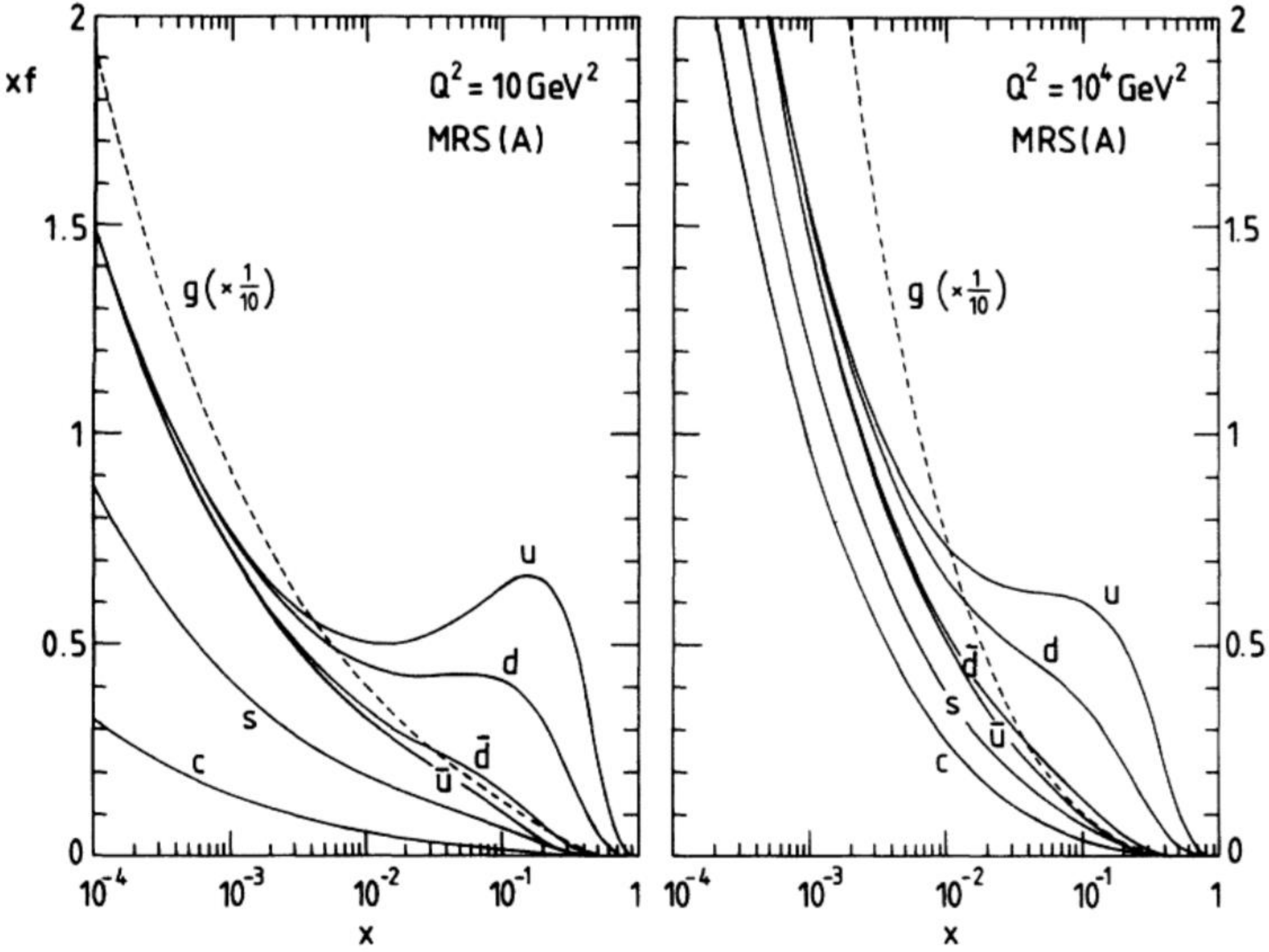


TABLE I. Experimental data used to determine the MRS parton distributions. The last column gives an indication of the main type of constraint imposed by a particular set of data.

Process/experiment	Leading-order subprocess	Parton determination
DIS ($\mu N \to \mu X$)	$\gamma^* q \to q$	Four structure functions$\to$
BCDMS, NMC		$u + \bar{u}$
$F_2^{\mu p}, F_2^{\mu n}$		$d + \bar{d}$
		$\bar{u} + \bar{d}$
DIS ($\nu N \to \mu X$)	$W^* q \to q'$	s (assumed$=\bar{s}$),
CCFR (CDHSW)		but only $\int xg(x)dx \simeq 0.5$
$F_2^{\nu N}, xF_3^{\nu N}$		[$\bar{u} - \bar{d}$ is not determined]
$\mu N \to c\bar{c}X$	$\gamma^* c \to c$	$c \approx 0.1s$ at Q_0^2
F_2^c, EMC		
$\nu N \to \mu^+\mu^- X$	$W^* s \to c$	$s \approx \frac{1}{2}\bar{u}$ (or $\frac{1}{2}\bar{d}$)
CCFR	$\hookrightarrow \mu^+$	
DIS (HERA)	$\gamma^* q \to q$	λ
F_2^{ep} (H1,ZEUS)		($x\bar{q} \sim xg \sim x^{-\lambda}$, via $g \to q\bar{q}$)
$pp \to \gamma X$	$qg \to \gamma q$	$g(x \approx 0.4)$
WA70 (UA6)		
$pN \to \mu^+\mu^- X$	$q\bar{q} \to \gamma^*$	$\bar{q} = \cdots (1-x)^{\eta_S}$
E605		
$pp, pn \to \mu^+\mu^- X$	$u\bar{u}, d\bar{d} \to \gamma^*$	$(\bar{u} - \bar{d})$ at x=0.18
NA51	$u\bar{d}, d\bar{u} \to \gamma^*$	
$p\bar{p} \to WX(ZX)$	$ud \to W$	u, d at $x_1 x_2 s \simeq M_W^2 \to$
UA2, CDF, D0		$x \approx 0.13$ CERN
		$x \approx 0.05$ Fermilab
$\to W^\pm$ asym		slope of u/d at $x \approx$0.05
CDF		



xf
$Q^2 = 10\ GeV^2$
MRS (A)
$g\ (\times \frac{1}{10})$
u
d
$\bar{d}$
$\bar{u}$
s
c
$Q^2 = 10^4\ GeV^2$
MRS (A)
$g\ (\times \frac{1}{10})$
u
d
$\bar{d}$
s
$\bar{u}$
c
x
x
2
1.5
1
0.5
0
10^{-4}
10^{-3}
10^{-2}
10^{-1}
1

MRS responded to new measurements and emphasized the importance of examining all data involving PDFs

1992-6 …. regularly updated MRS PDFs

e.g. in 1996 -- MRS fits were able to include new precise HERA DIS data + Fermilab jet data

One consequence: $\alpha_s \sim 0.113 \rightarrow 0.116 - 0.120$

Then in 1997 a major event happened

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