
A study of compatibility

Table of Data Sets

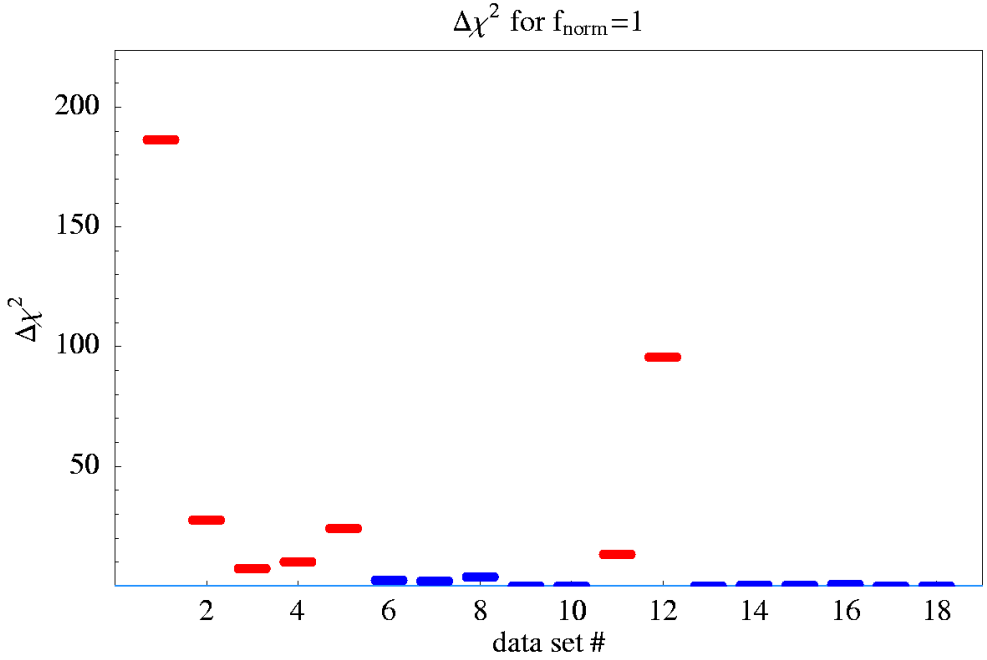
The PDF's are not exactly CTEQ6 but very close – a no-name generic set of PDF's for illustration purposes.

$$N_{\text{tot}} = 2291$$

$$\chi^2_{\text{global}} = 2368.$$

		N	χ^2	χ^2/N
1	BCDMS F2p	339	366.1	1.08
2	BCDMS F2d	251	273.6	1.09
3	H1 (a)	104	97.8	0.94
4	H1 (b)	126	127.3	1.01
5	H1 (c)	129	108.9	0.84
6	ZEUS	229	261.1	1.14
7	CDHSW F2	85	65.6	0.77
8	NMC F2p	201	295.5	1.47
9	NMC d/p	123	115.4	0.94
10	CCFR F2	69	84.9	1.23
11	E605	119	94.7	0.80
12	E866 pp	184	239.2	1.30
13	E866 d/p	15	5.0	0.33
14	D0 jet	90	62.6	0.70
15	CDF jet	33	56.1	1.70
16	CDHSW F3	96	76.4	0.80
17	CCFR F3	87	26.8	0.31
18	CDF W Lasy	11	8.7	0.79

The effect of setting all normalization constants to 1.



$\Delta\chi^2$

1	BCDMS F2p	186.5
2	BCDMS F2d	27.6
3	H1 (a)	7.3
4	H1 (b)	10.1
5	H1 (c)	24.0
8	NMC F2p	4.0
11	E605	13.3
12	E866 pp	95.7

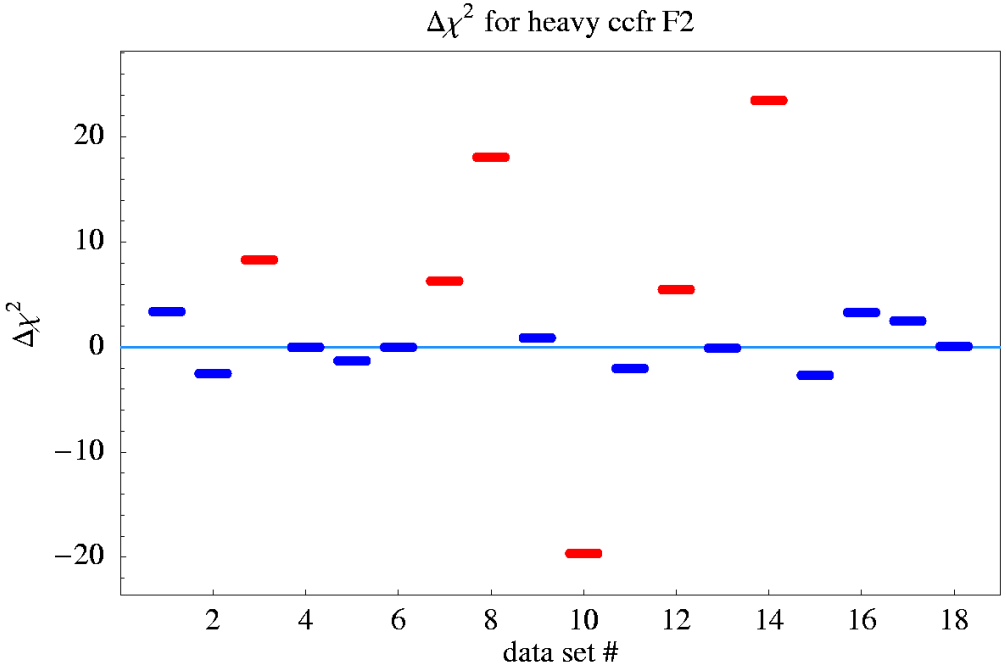
χ^2 (opt. norm) = 2368.

χ^2 (norm 1) = 2742.

$\Delta\chi^2$ = 374.0

By applying weighting factors in the fitting function, we can test the "compatibility" of disparate data sets.

Example 1. The effect of giving the CCFR F2 data set a heavy weight.

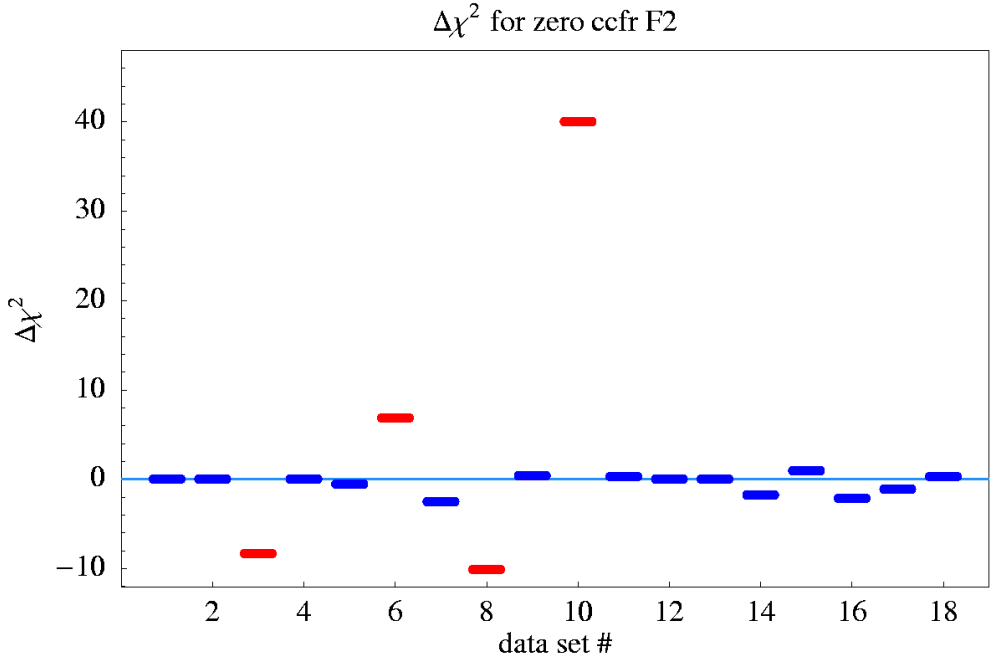


		$\Delta\chi^2$
3	H1 (a)	8.3
7	CDHSW F2	6.3
8	NMC F2p	18.1
10	CCFR F2	–19.7
12	E866 pp	5.5
14	D0 jet	23.5

$\Delta\chi^2$ (CCFR) = –19.7
$\Delta\chi^2$ (other) = +63.3

Giving a single data set a large weight is tantamount to determining the PDF's from that data set alone. The result is a significant improvement for that data set but which does not fit the others.

Example 1b. The effect of giving the CCFR F2 data weight 0, i.e., removing the data set from the global analysis.



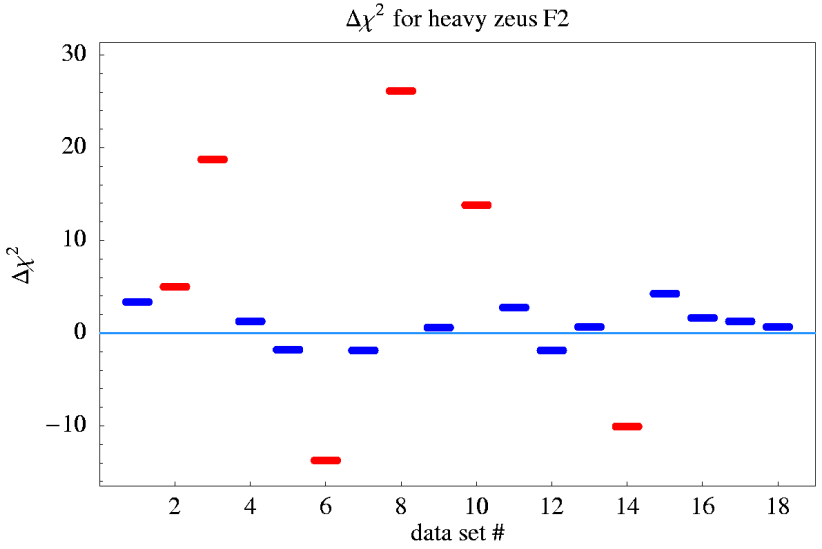
$\Delta\chi^2$

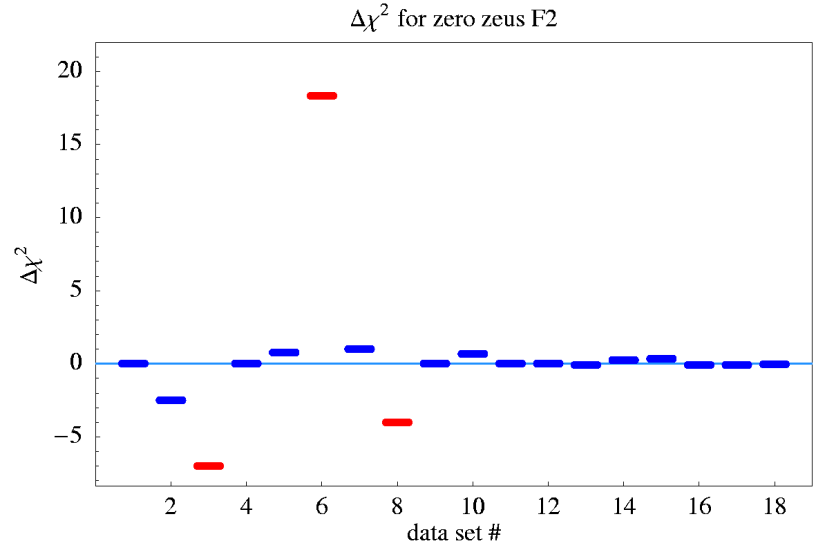
3	H1 (a)	−8.3
6	ZEUS	6.9
8	NMC F2p	−10.1
10	CCFR F2	40.0

$\Delta\chi^2$ (CCFR) = +40.0
$\Delta\chi^2$ (other) = −17.4

Imagine starting with the other data sets, not including CCFR. The result of adding CCFR is that χ^2_{global} of the other sets increases by 17.4 ; this must be an acceptable increase of χ^2 .

Example 2. ZEUS F2 measurements





Heavy weight for ZEUS

(Like fitting ZEUS alone)

2	BCDMS F2d	5.0
3	H1 (a)	18.7
6	ZEUS	–13.7
8	NMC F2p	26.1
10	CCFR F2	13.8
14	D0 jet	–10.1
15	CDF jet	4.3

$\Delta\chi^2$ (zeus) = –13.7

$\Delta\chi^2$ (other) = +64.6

Zero weight for ZEUS

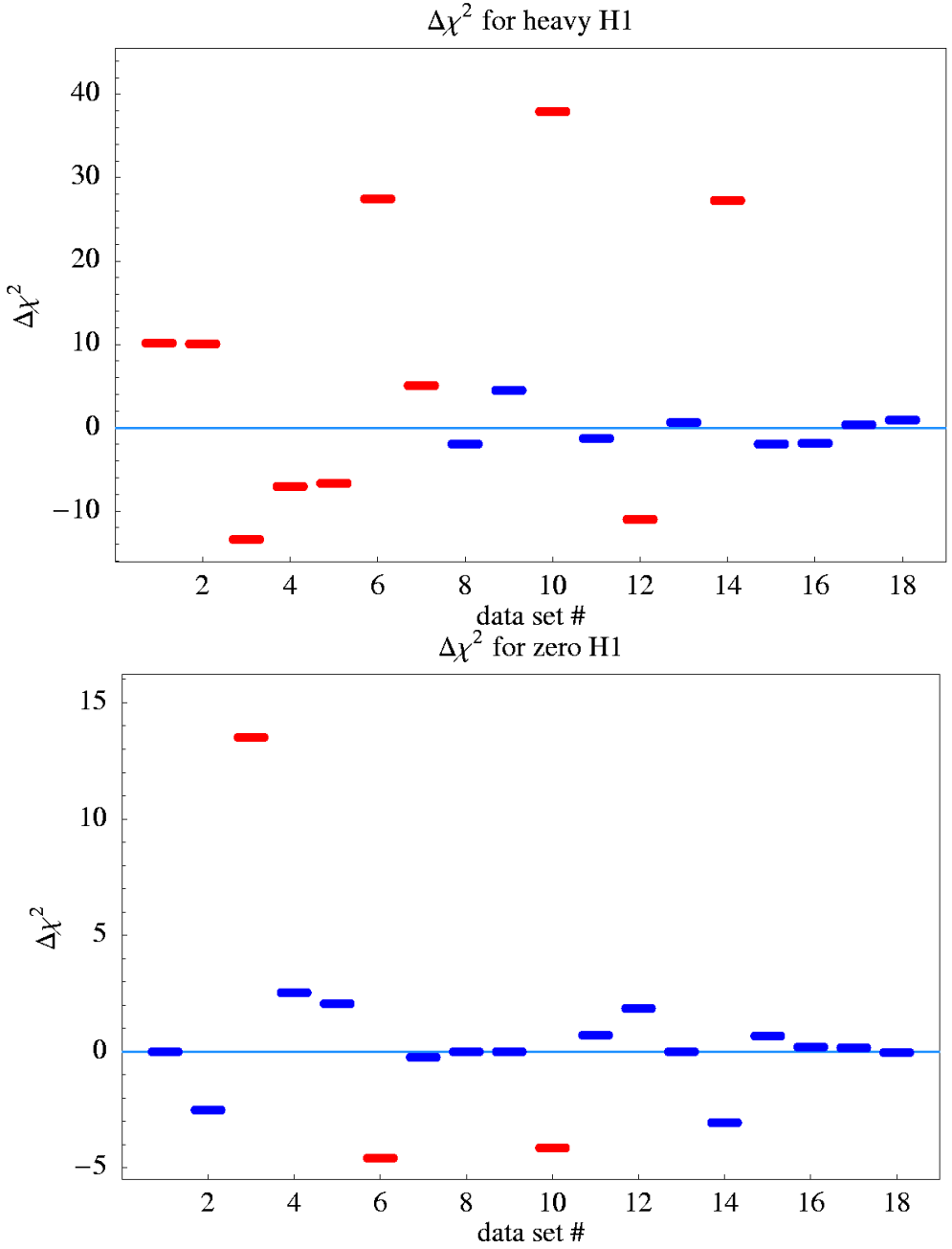
3	H1 (a)	–7.0
6	ZEUS	18.3
8	NMC F2p	–4.0

$\Delta\chi^2$ (zeus) = +18.3

$\Delta\chi^2$ (other) = –10.6

[removing zeus => χ2 (other) decreases by 10.6]

Example 3. H1 data sets



Heavy weight for H1 data

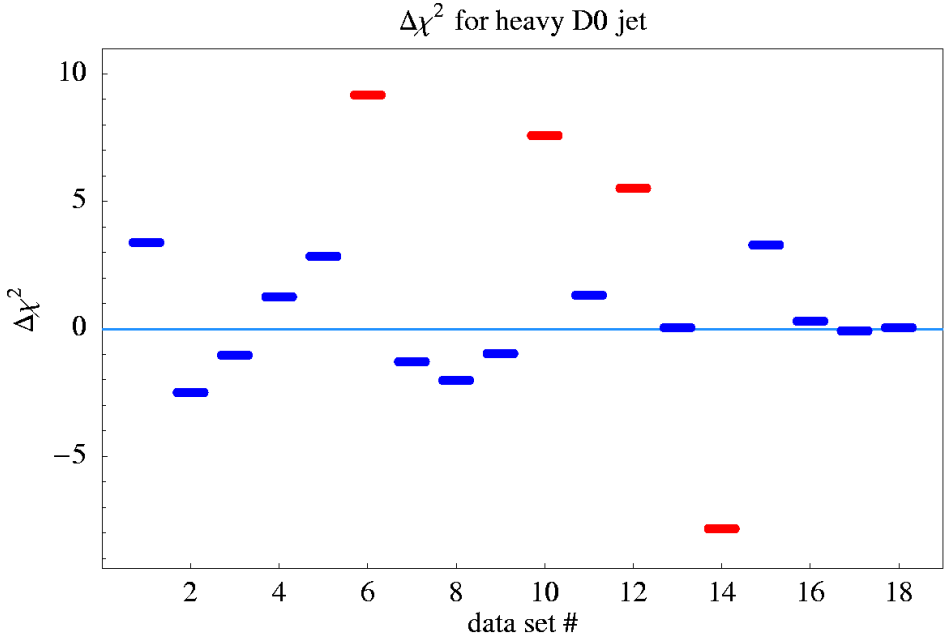
		$\Delta\chi^2$
1	BCDMS p	10.2
2	BCDMS d	10.0
3	H1 (a)	−13.4
4	H1 (b)	−7.1
5	H1 (c)	−6.7
6	ZEUS	27.5
7	CDHSW	5.0
10	CCFR F2	37.9
12	E866 pp	−11.0
14	D0 jet	27.3

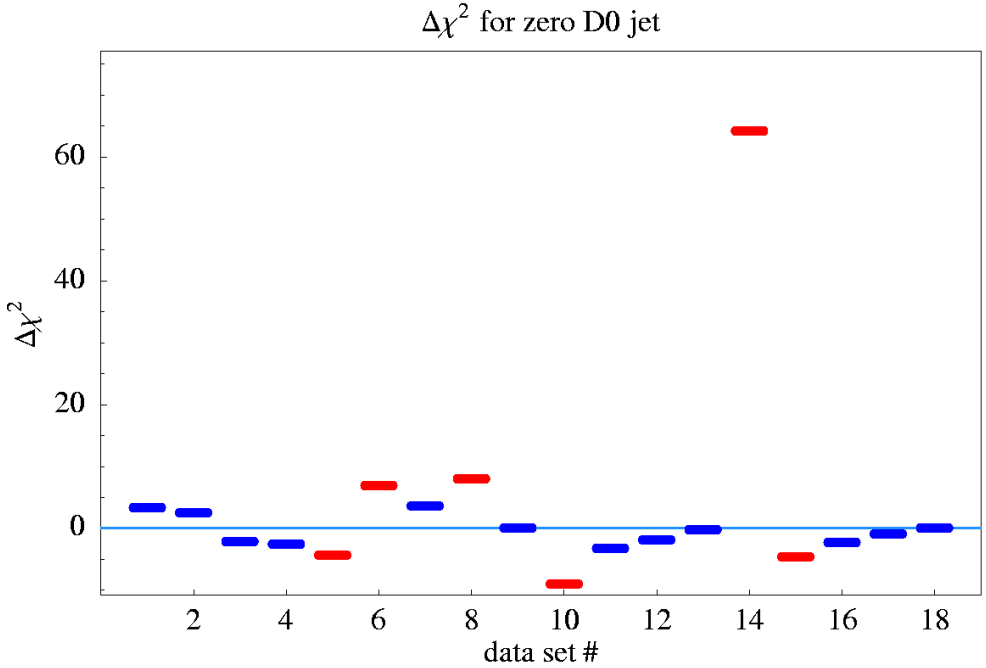
$\Delta\chi^2$ (H1) = −27.2
$\Delta\chi^2$ (other) = +106.1

Zero weight for H1

		$\Delta\chi^2$
3	H1 (a)	13.5
6	ZEUS	−4.6
10	CCFR F2	−4.1

$\Delta\chi^2$ (H1) = +18.1
$\Delta\chi^2$ (other) = −11.0





Example 4. The D0 jet cross section

Heavy weight for D0 jet

6	ZEUS	9.2
10	CCFR F2	7.6
12	E866 pp	5.5
14	D0 jet	−7.8

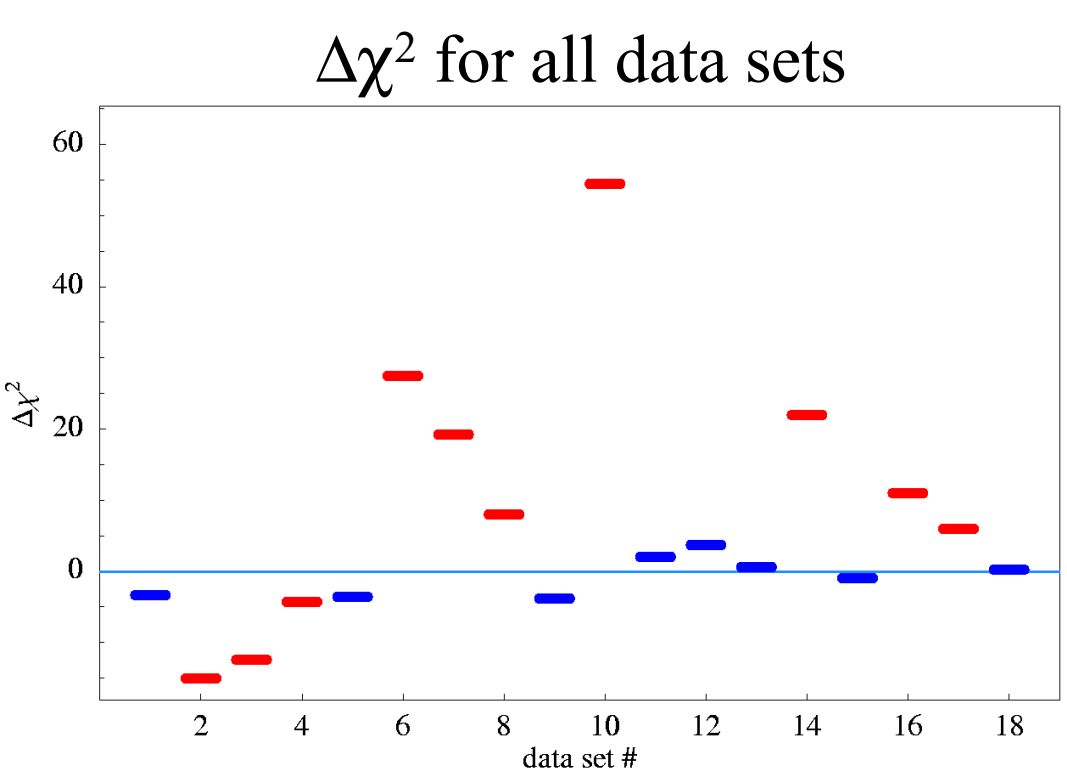
$\Delta\chi^2$ (D0 jet) = −7.8
$\Delta\chi^2$ (other) = +26.8

Zero weight for D0 jet

5	H1 (c)	−4.3
6	ZEUS	6.9
8	NMC F2p	8.0
10	CCFR F2	−9.0
14	D0 jet	64.3
15	CDF jet	−4.6

$\Delta\chi^2$ (D0 jet) = +64.3
$\Delta\chi^2$ (other) = −6.5

Example 5. Giving heavy weight to H1 and BCDMS



		$\Delta\chi^2$
2	BCDMS F2d	–15.1
3	H1 (a)	–12.4
4	H1 (b)	–4.3
6	ZEUS	27.5
7	CDHSW F2	19.2
8	NMC F2p	8.0
10	CCFR F2	54.5
14	D0 jet	22.0
16	CDHSW F3	11.0
17	CCFR F3	5.9

$\Delta\chi^2(\text{H \& B}) = -38.7$

$\Delta\chi^2(\text{other}) = +149.9$

Lessons from these *reweighting* studies

• Global analysis requires compromises – the PDF model that gives the best fit to one set of data does not give the best fit to others. This is not surprising because there are systematic differences between the experiments.

• The scale of acceptable changes of χ^2 must be large. Adding a new data set and refitting may increase the χ^2's of other data sets by amounts >> 1.

Clever ways to test the compatibility of disparate data sets

- Plot χ^2 versus χ^2

J Collins and J Pumplin (hep-ph/0201195)

- The Bootstrap Method

Efron and Tibshirani, Introduction to the Bootstrap (Chapman&Hall)
Chernick, Bootstrap Methods (Wiley)