Systematic errors in the ABM fit

$$\chi^2(\theta) = \sum_{i,j=1}^{NDP} (f_i(\theta) - y_i) E_{ij} (f_j(\theta) - y_j)$$

$$E_{ij} = (C^{-1})_{ij}$$

$$C_{ij} = \eta_i \eta_j t_i t_j + \delta_{ij} \sigma_i \sigma_j$$

Common χ^2 estimator: efficient and asymptotically unbiased without correlations

y – measurement

f(θ) – theory

σ – statistical error

η – systematic error

t=y – the estimator is biased

t=f(θ) – estimator is asymptotically unbiased

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Philosophy

- The correlations are taken into account whenever information is available
- The normalization uncertainties are included on the same footing as other systematics, if the normalization was calibrated in the experiment.; the normalization is fixed in this case
- Otherwise the normalization is fitted parameter; the errors in the normalization obtained from the fit are included into the general error matrix and in this way are propagated into the PDF errors.

Fixed-normalization data sets

H1+ZEUS	The absolute normalization of 0.5%, 113 sources of the correlated systematics	**JHEP 1001, 109 (2010)**
H1	The absolute normalization is 3%, 8 sources of the correlated systematics	**EPJC 71, 1579 (2011)**
BCDMS	The general normalization uncertainty of 3%, an additional normalization uncertainty of 1-1.5% for each beam energy; 5 sources of correlated systematics.	**PLB 223, 485 (1989)** **PLB 237, 592 (1990)**
FNAL-E-605	The absolute normalization uncertainty is 15%, one source of the correlated systematics	**PRD 43, 2815 (1991)**
FNAL-E-866	No normalization uncertainty (cancels in the pD/pp ratio); 5 sources of correlated systematics	**PRD 64, 052002 (2001)**
NuTeV	8 independent sources of systematics; the normalization error is included into the flux uncertainty (marginal due to calibration with the inclusive data sample)	**PRD 64, 112006 (2001)**
CCFR	Only combined systematic errors are available; considered as a one source of the correlated systematics. The normalization uncertainty Is the same with the NuTeV data	**PRD 64, 112006 (2001)**

Fitted-normalization data sets (SLAC)

Whitlow et al. PLB 250, 193 (1990)

Experiment	Target	NDP	NSE	Norm.
E-49A	p	59	3	1.019
	D	59	3	1.000
E-49b	p	154	3	1.025
	D	145	3	1.005
E-87	p	109	3	1.029
	D	109	3	1.013
E-89a	p	77	4	1.
	D	71	5	1.
E-89b	p	90	3	1.012
	D	72	3	0.992
E-139	D	17	3	1.010
E-140	D	26	4	1.

- The E-140 data normalization was calibrated in the experiment, the normalization uncertainty of 1.7%
- The E-89a data normalization was tuned to the elastic data; the general normalization of 2.8% and additional normalization uncertainty of 0.5 % for the deuterium sample
- The rest of samples were fitted in [PLB 250, 193 (1990)] to the E-140 data with the E-49b used as a bridge between the proton and deuterium samples, In our fit the deuteron samples are driven by E-140 and the proton samples by BCDMS and (indirectly) by HERA
- 3 additional sources of correlated systematics for each data set

Fitted-normalization data sets (NMC)

NPB 483, 3 (1997)

Beam energy (GeV)	Target	Norm.
90	p	1.008
	D	0.986
120	p	1.021
	D	1.000
200	p	1.029
	D	1.010
280	p	1.022
	D	1.003

- The data were normalized to combination of SLAC and BCDMS data in [NPB 483, 3 (1997)]
- In our fit the proton NMC sample normalization is driven by HERA and the deuterium one by SLAC
- 12 sources of correlated uncertainties (some of them correlated between different targets and some between different energies)

Summary of systematics in ABM11 fit

Experiment	NDP	NSE (corr.+ norm.)	R
H1+ZEUS	486	114	0.3
H1	130	9	0.8
BCDMS	605	10	0.7
SLAC-E-49a	118	3	0.2
SLAC-E-49b	299	3	0.3
SLAC-E-87	218	3	0.4
SLAC-E-89a	148	5	0.6
SLAC-E-89b	162	3	0.5
SLAC-E-139	17	3	0.4
SLAC-E-140	26	4	0.9
NMC	490	12	0.4
FNAL-E-605	119	2	0.8
FNAL-E-866	39	5	0.3
NuTeV	89	8	0.4
CCFR	89	1	0.1
Total	3036	190	0.2

The value of R shows statistical significance of the error correlations: R=1 correspond to the case of fully point-to-point correlated error

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