PDF sensitivities using W,Z,γ^* at LHCb

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Pseudo-data fits to deduce improvements in PDFs

- From eigenvector phase space (assume multinomial distribution), choose one set: **'truth'**
- Generate many pseudo-data sets corresponding to given luminosity
- Fit each pseudo-data set: **'pseudo-measurement'**
- Compare **pseudo-measurement** to **truth**
  - centre of distribution gives bias
  - width of distribution gives precision
- Repeat

What is fit? (MSTW,CTEQ,Alekhin)

We considered $\dfrac{d\sigma}{dy}$ for W+,W-,Z.

$f_0 = \dfrac{d\sigma}{dy}$: distribution obtained with central eigenvectors

$f_i = \dfrac{d\sigma}{dy}(\lambda_i = 1, \lambda_{\neq i} = 0)$: distribution with i^{th} e.v. moved 1σ

Fit

$$\chi^2(\lambda_0, \lambda_i) = \sum_{j=1}^{\#bins}\left[\frac{x_j - \lambda_0\left(f_0 + \lambda_i\left(f_i - f_0\right)\right)}{\sigma_j}\right]^2 + \sum_{i=1}^{\#e.v.}\lambda_i^2$$

Normalisation (Luminosity)

data in j bins, each with uncertainty σ

Eigenvalues

Results for precision on luminosity shown at DIS09....

	0.1 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	1.8	2.4	2.0	2.9
W-	1.9	2.6	2.2	2.7
Z	1.9	2.4	2.2	2.4
WWZ	1.7	2.3	1.8	2.0
	1 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	1.6	2.2	1.8	2.4
W-	1.6	2.3	2.1	2.4
Z	1.7	2.1	1.9	1.8
WWZ	1.3	2.1	1.4	2.2
	10 fb^{-1}			
	MSTW08	CTEQ66	Alekhin	NNPDF
W+	1.3	2.0	1.5	2.5
W-	1.2	1.9	1.6	3.0
Z	1.4	1.9	1.9	1.9
WWZ	0.8	1.7	1.0	-

Percentage statistical uncertainty on fitted luminosity

Precision doesn't scale with $\frac{1}{\sqrt{N_{events}}}$

Covariance matrix

$$\chi^2(\lambda_0,\lambda_i) = \sum_{j=1}^{\#bins}\left[\frac{x_j - \lambda_0\left(f_0 + \lambda_i\left(f_i - f_0\right)\right)}{\sigma_j}\right]^2 + \sum_{i=1}^{\#e.v.}\lambda_i^2$$

Before:

$$V_{ij} = \begin{pmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

After:

$$V_{ij} = \begin{pmatrix} <1 & \neq 0 & \neq 0 & \neq 0 \\ \neq 0 & <1 & \neq 0 & \neq 0 \\ \neq 0 & \neq 0 & <1 & \neq 0 \\ \neq 0 & \neq 0 & \neq 0 & <1 \end{pmatrix}$$

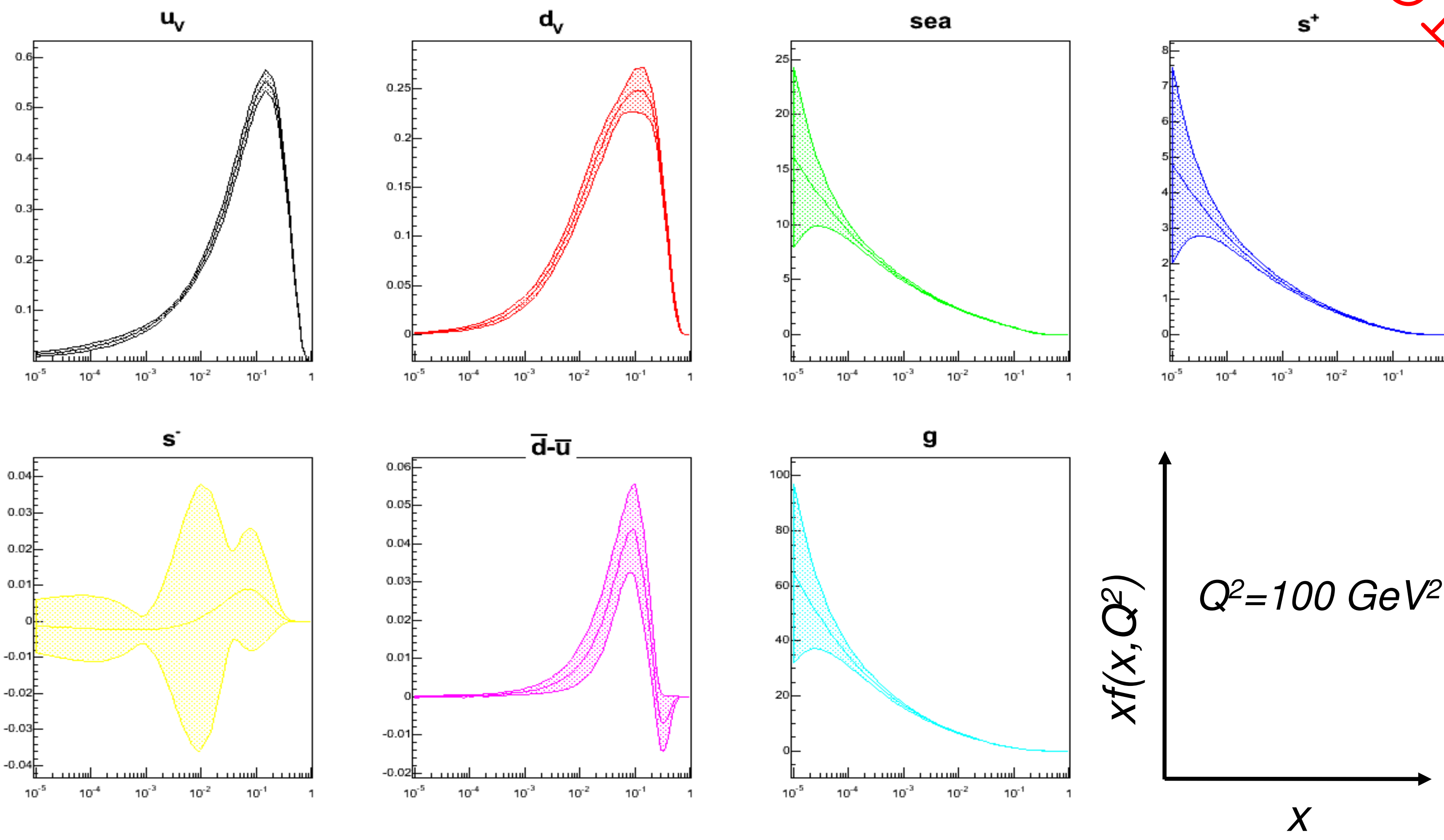
For any quantity $f(\lambda_i)$

$$\delta_f = \sum_{ij}\frac{\partial f}{d\lambda_i}V_{ij}^{-1}\frac{\partial f}{d\lambda_j}$$

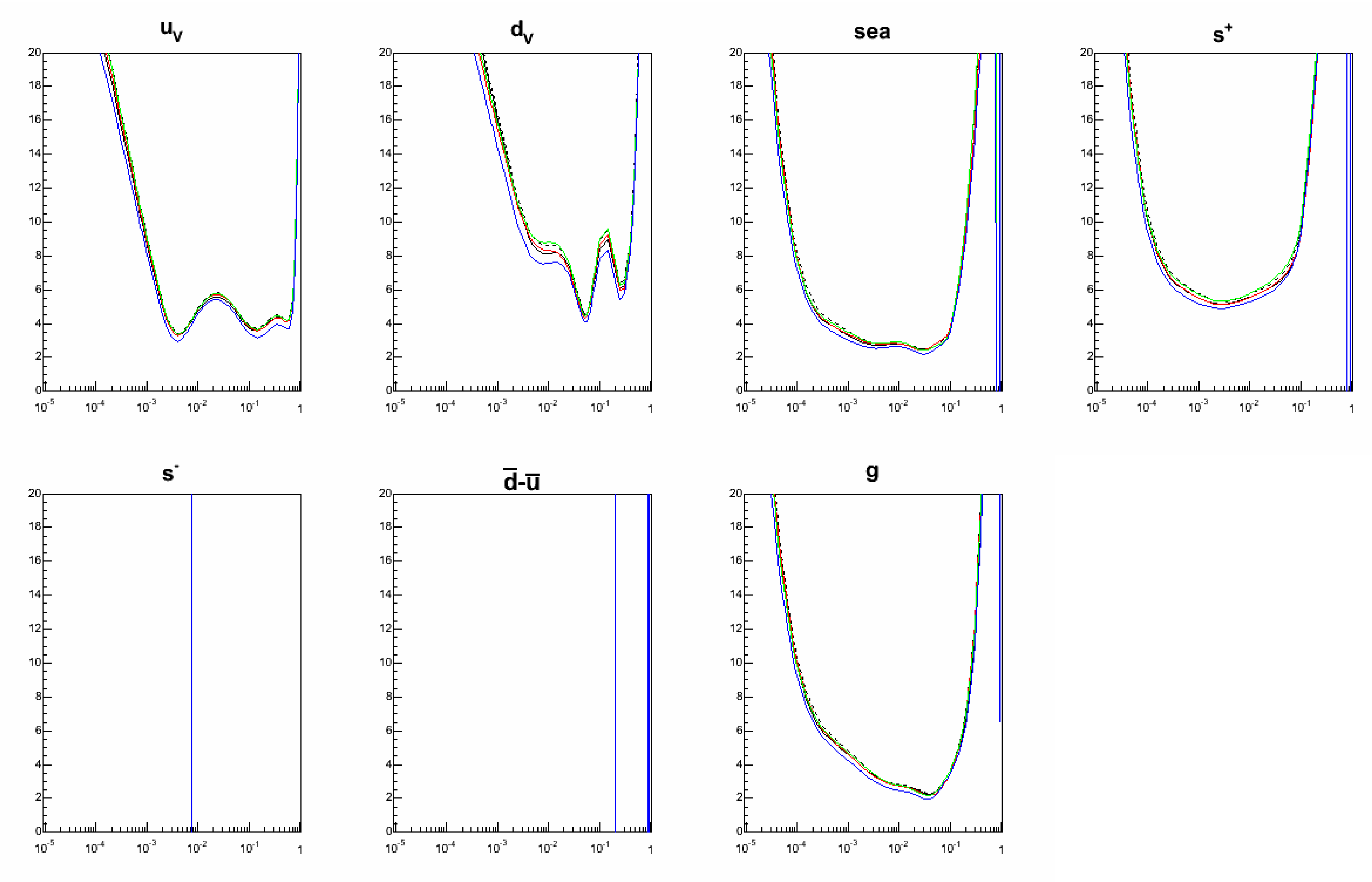
so modified PDFs can be deduced.

MSTW08 PDF

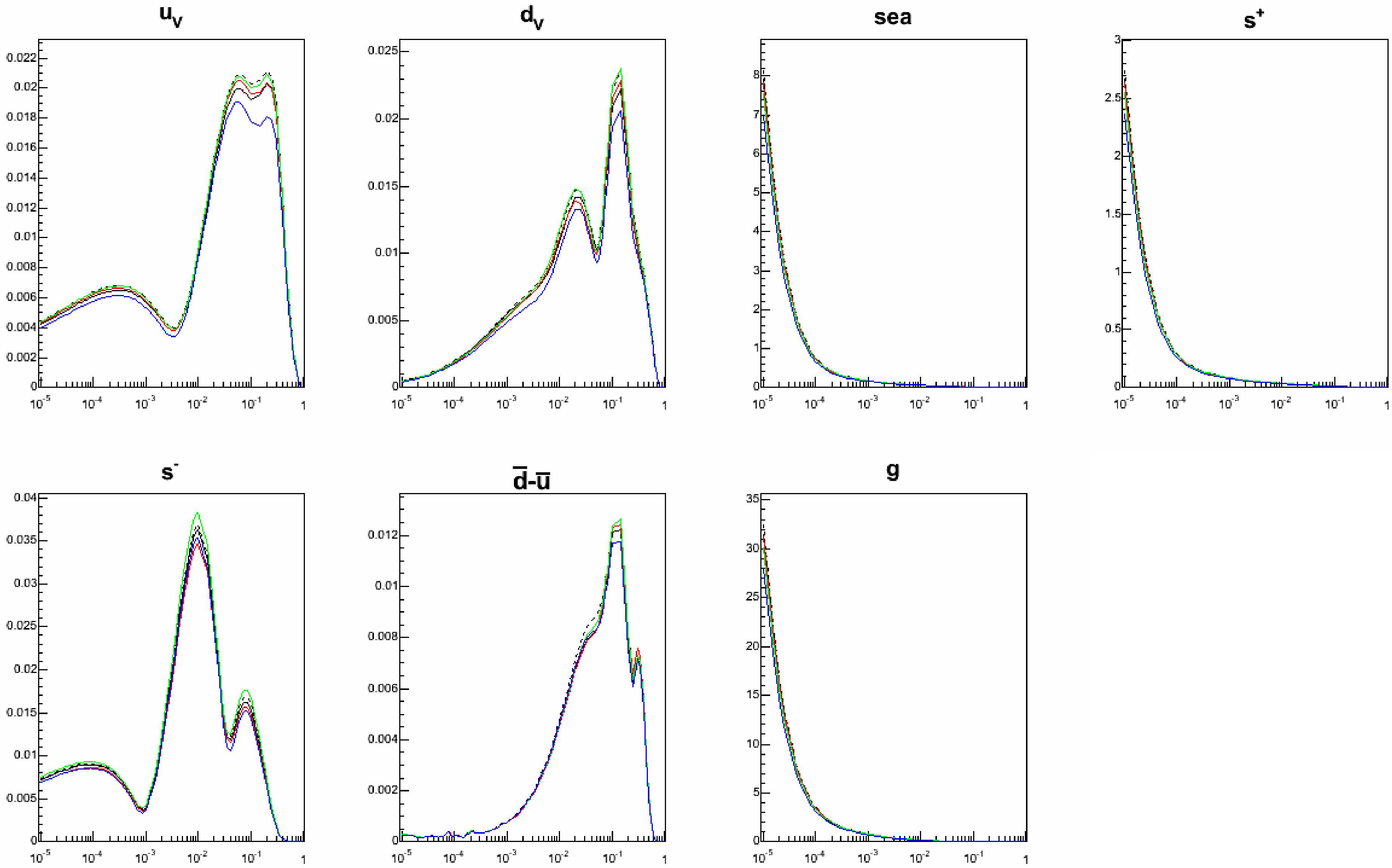
theory



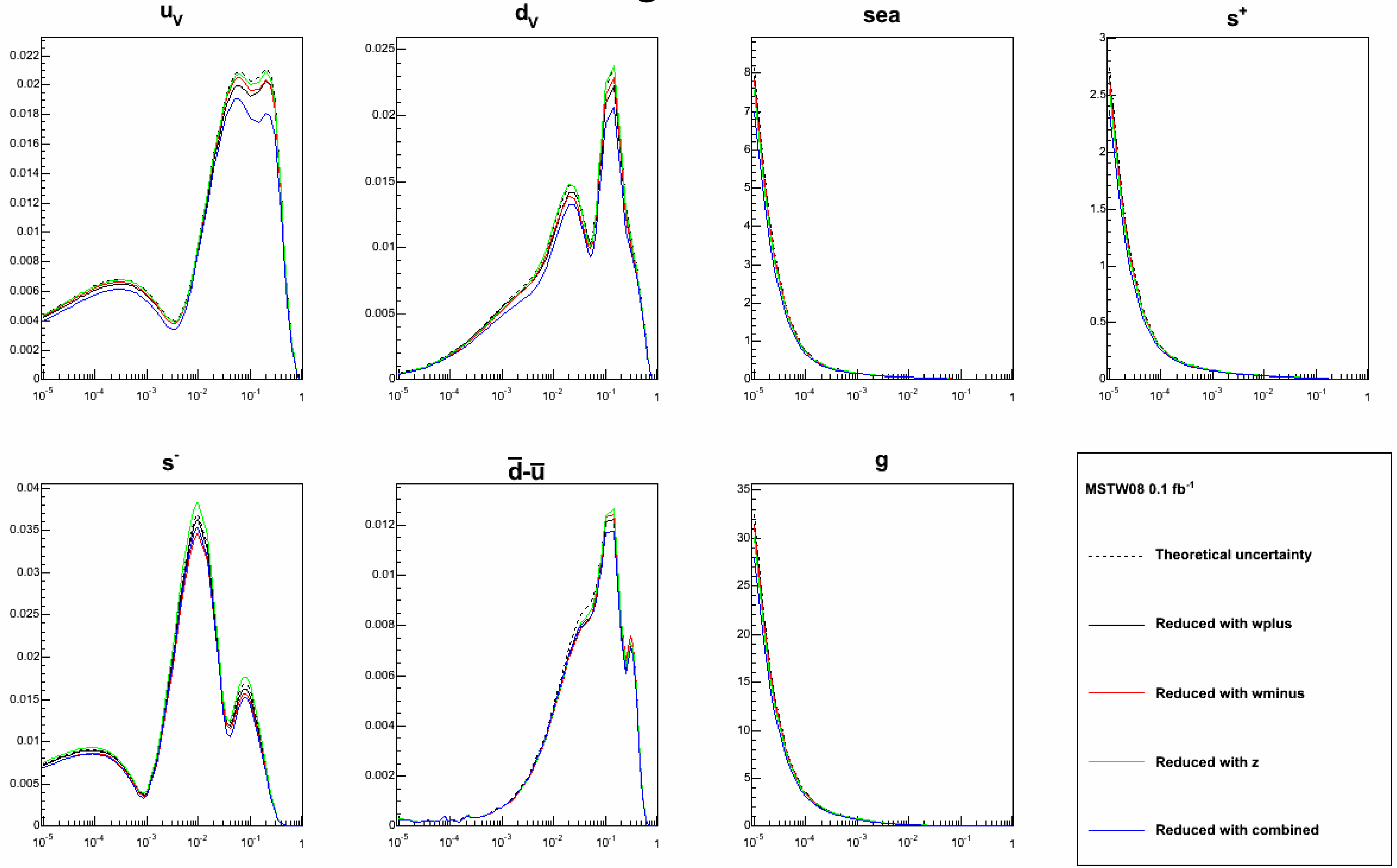
% uncertainty for MSTW08 Q^2=100 GeV^2



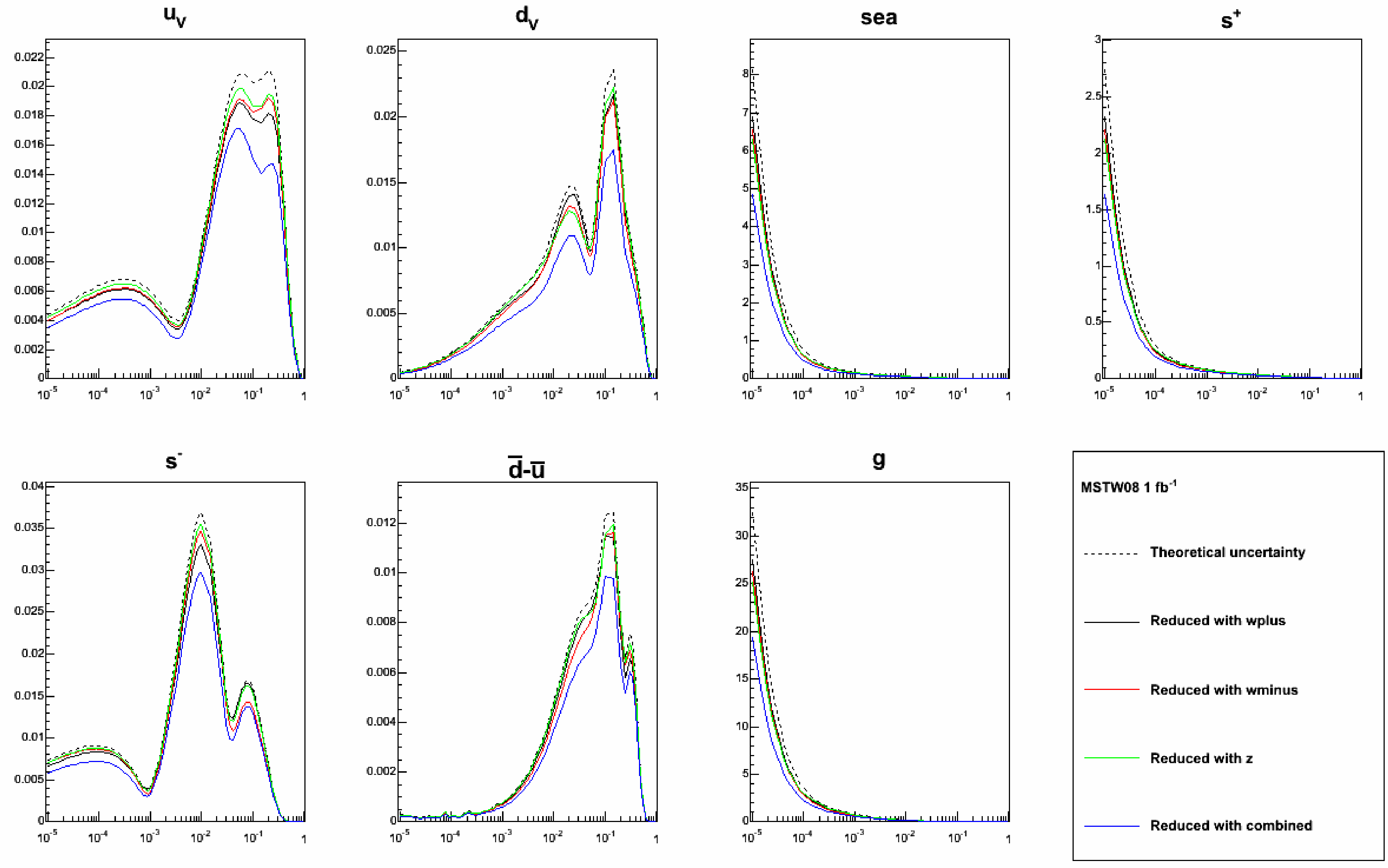
Absolute uncertainty for MSTW08 Q^2=100 GeV^2



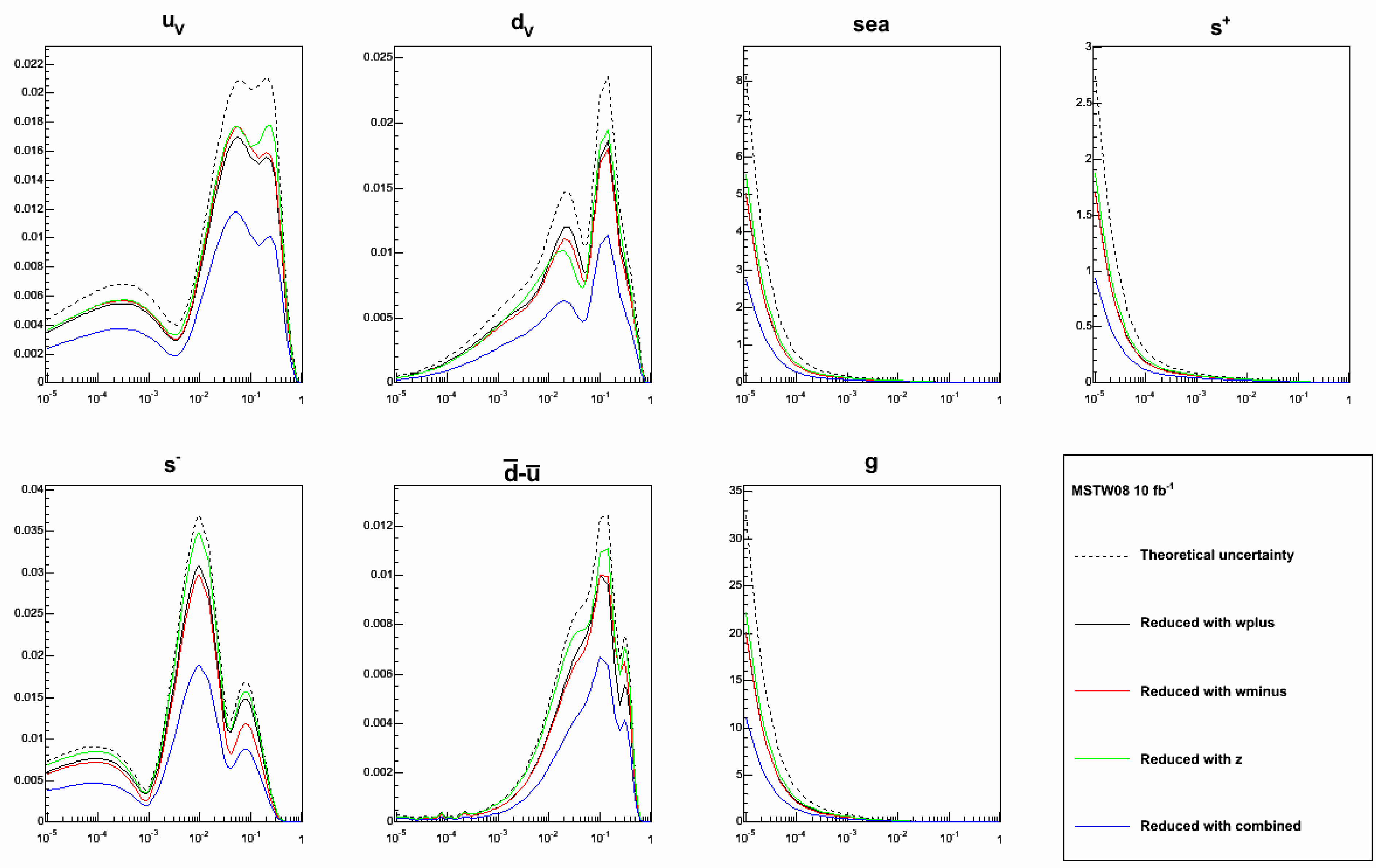
Effect on absolute uncertainty for MSTW08 at Q^2=100 GeV^2 using **0.1fb-1** of LHCb data



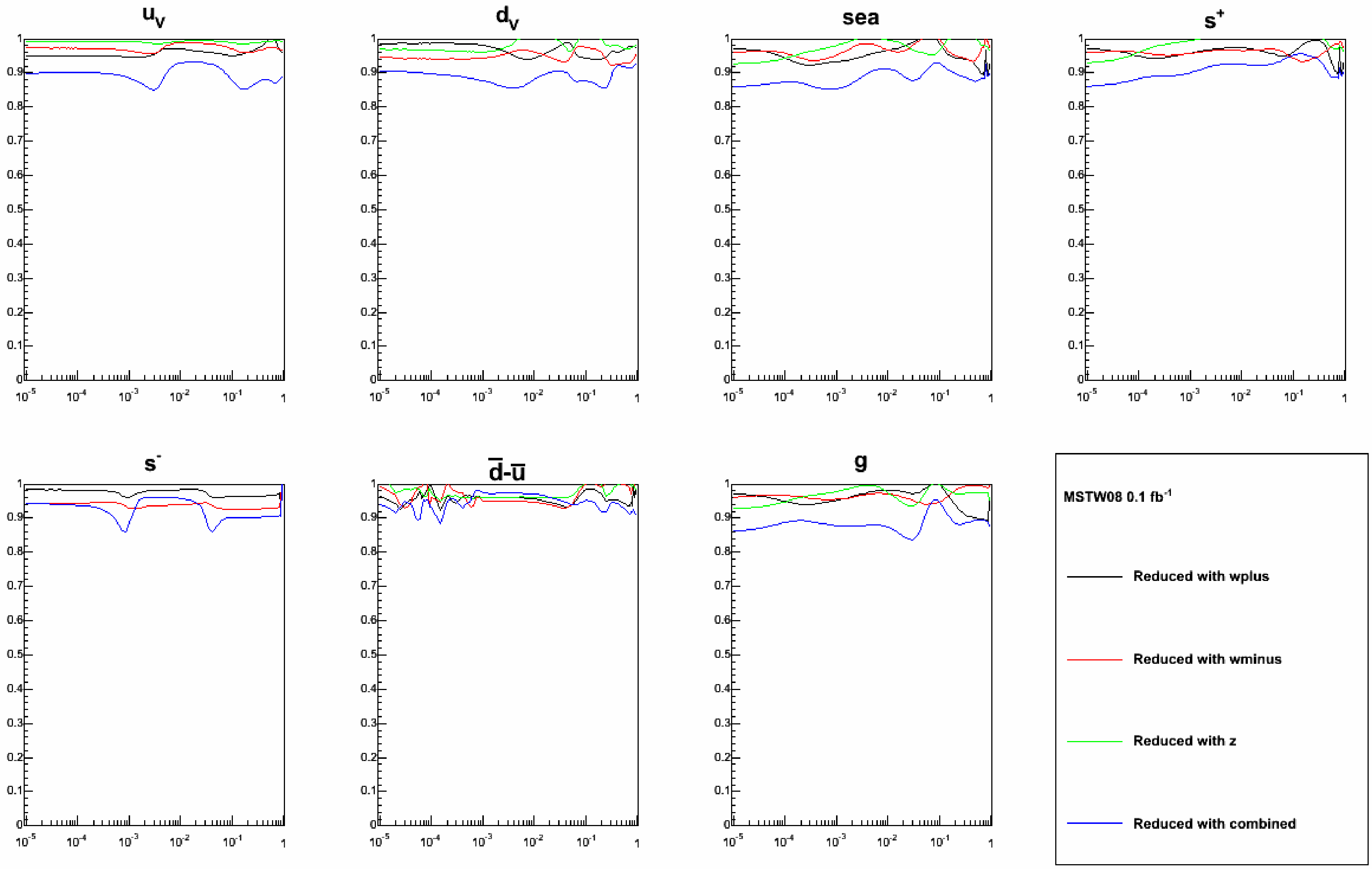
Effect on absolute uncertainty for MSTW08 at Q^2=100 GeV^2 using **1fb-1** of LHCb data



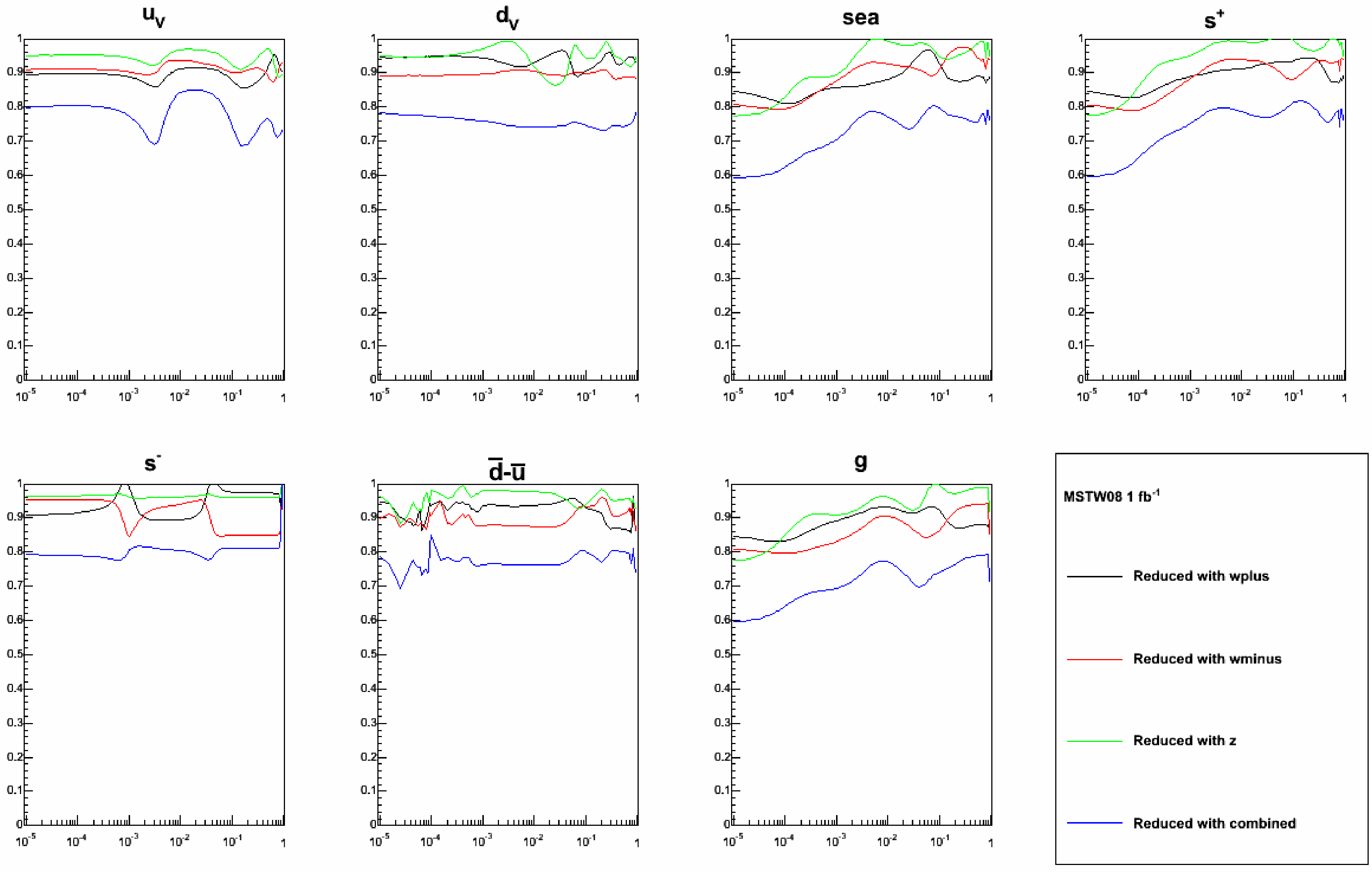
Effect on absolute uncertainty for MSTW08 at Q^2=100 GeV^2 using **10fb-1** of LHCb data



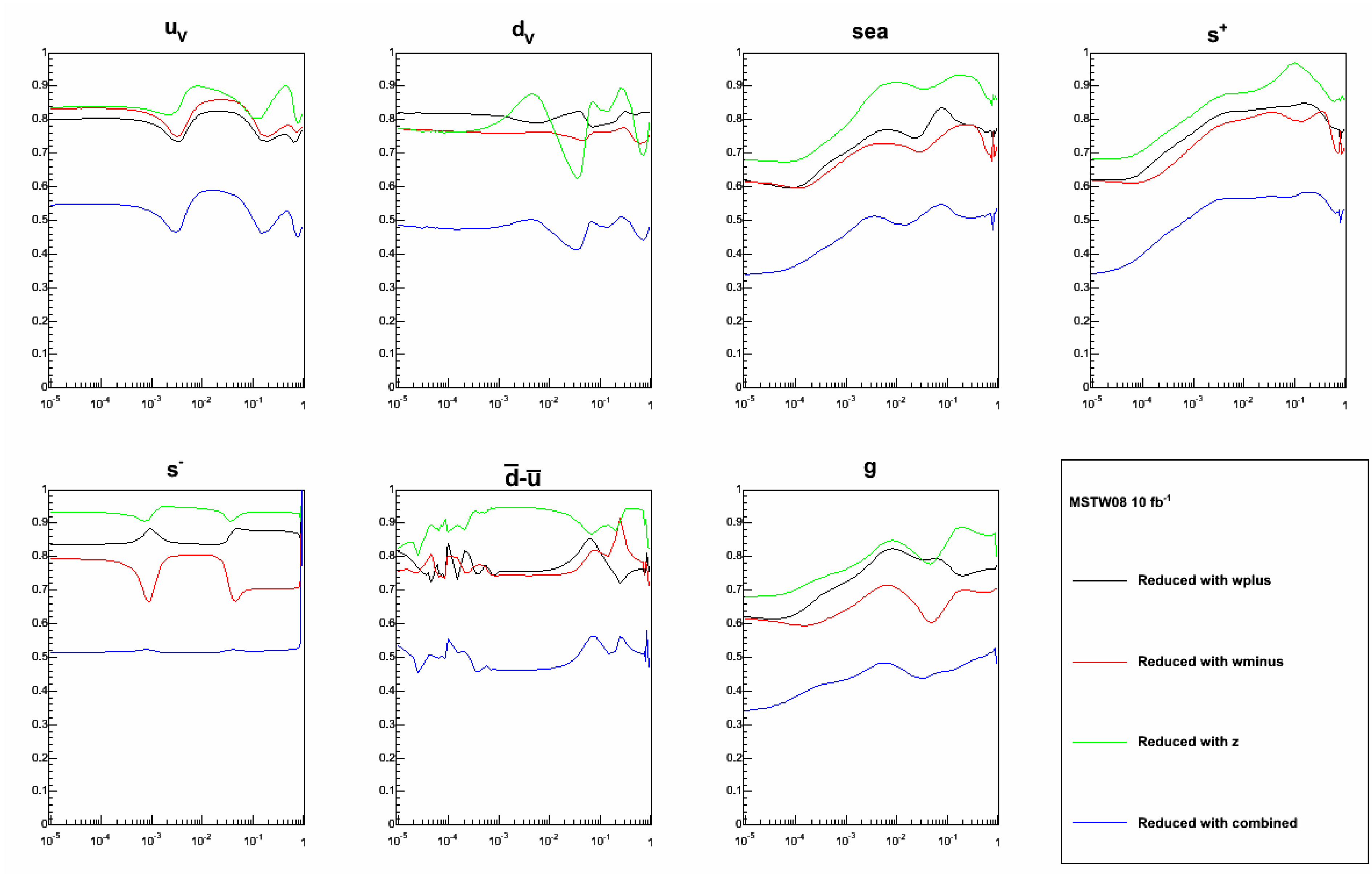
Ratio of uncertainty after fit to before for MSTW08 at Q^2=100 GeV^2 using **0.1 fb-1** of LHCb data



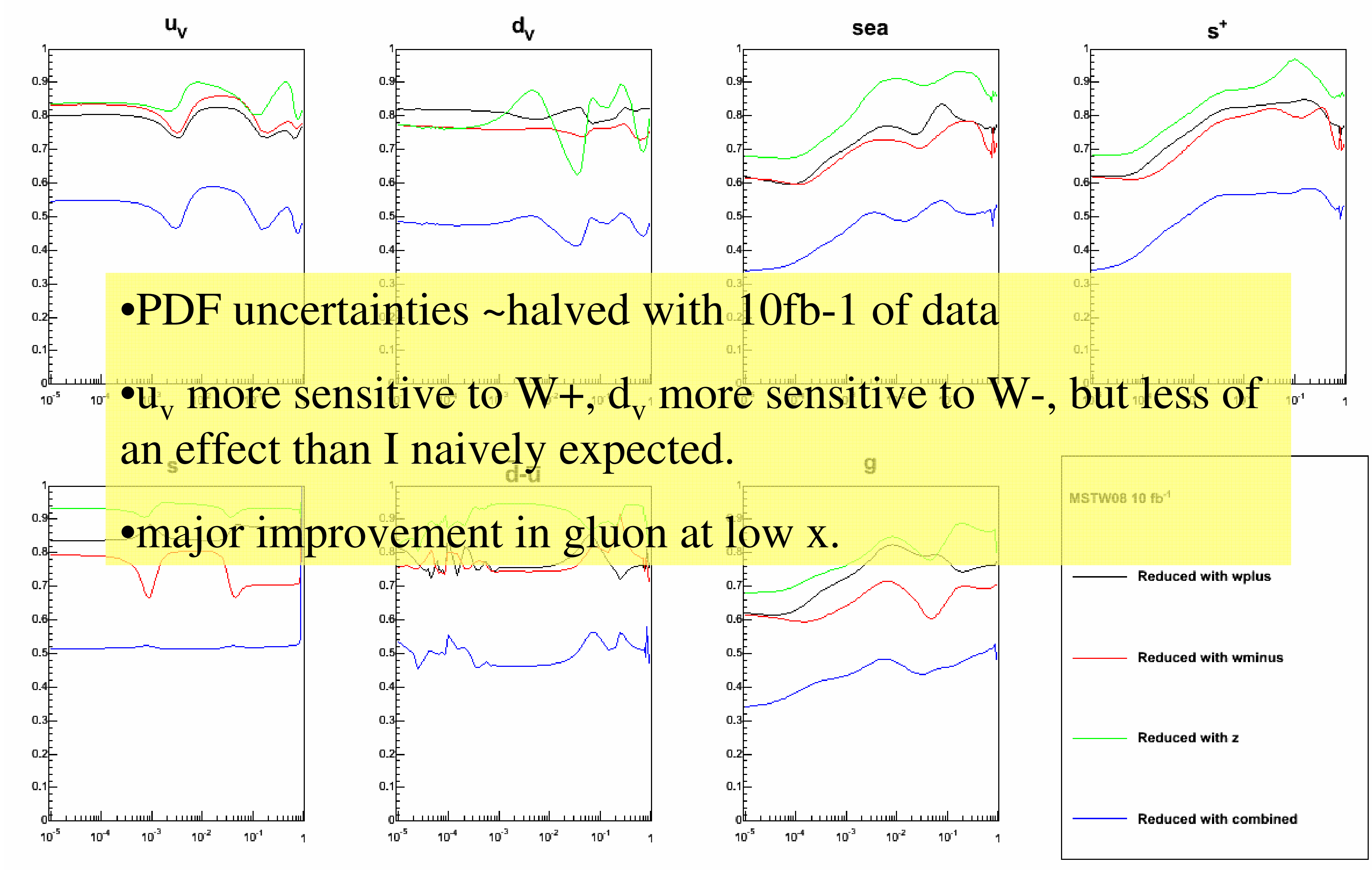
Ratio of uncertainty after fit to before for MSTW08 at Q^2=100 GeV^2 using **1 fb-1** of LHCb data



Ratio of uncertainty after fit to before for MSTW08 at Q^2=100 GeV^2 using **10 fb-1** of LHCb data



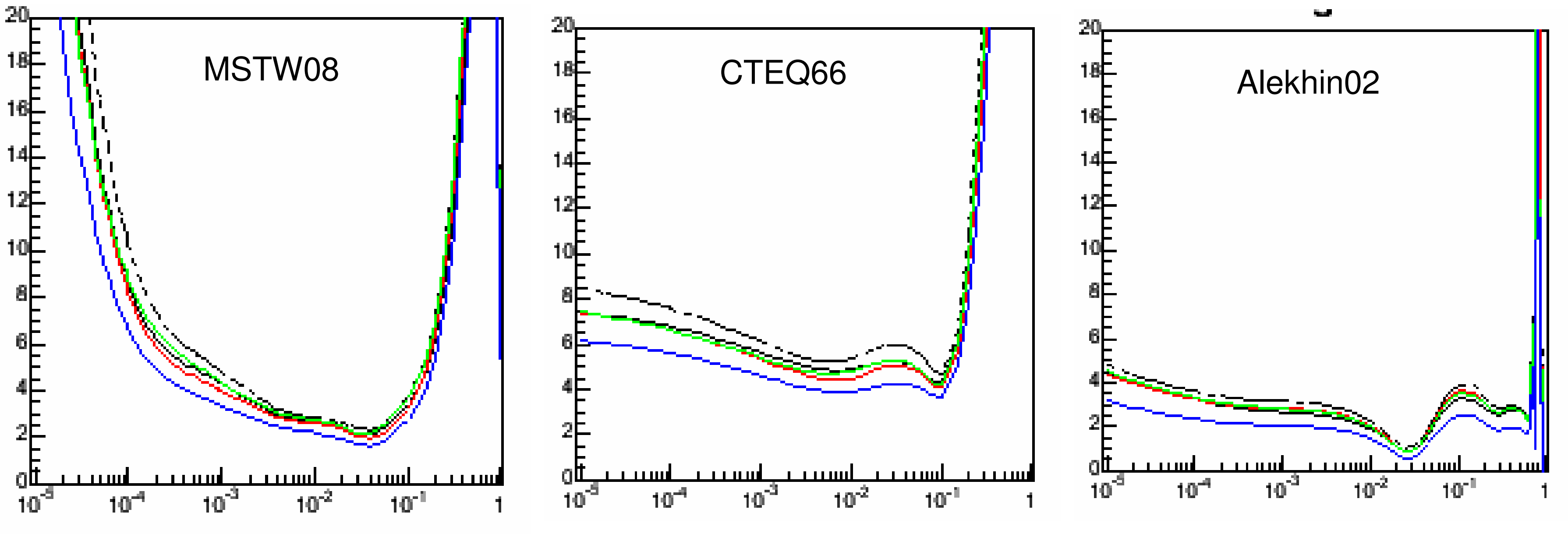
Ratio of uncertainty after fit to before for MSTW08 at Q^2=100 GeV^2 using **10 fb-1** of LHCb data



- PDF uncertainties ~halved with 10fb-1 of data
- u_v more sensitive to W+, d_v more sensitive to W-, but less of an effect than I naively expected.
- major improvement in gluon at low x.

First look at effect on other PDF sets

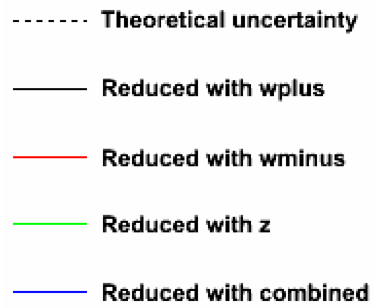
Effect on gluon PDF with fit to $1 fb^{-1}$ of LHCb data at $Q^2=100$ GeV^2



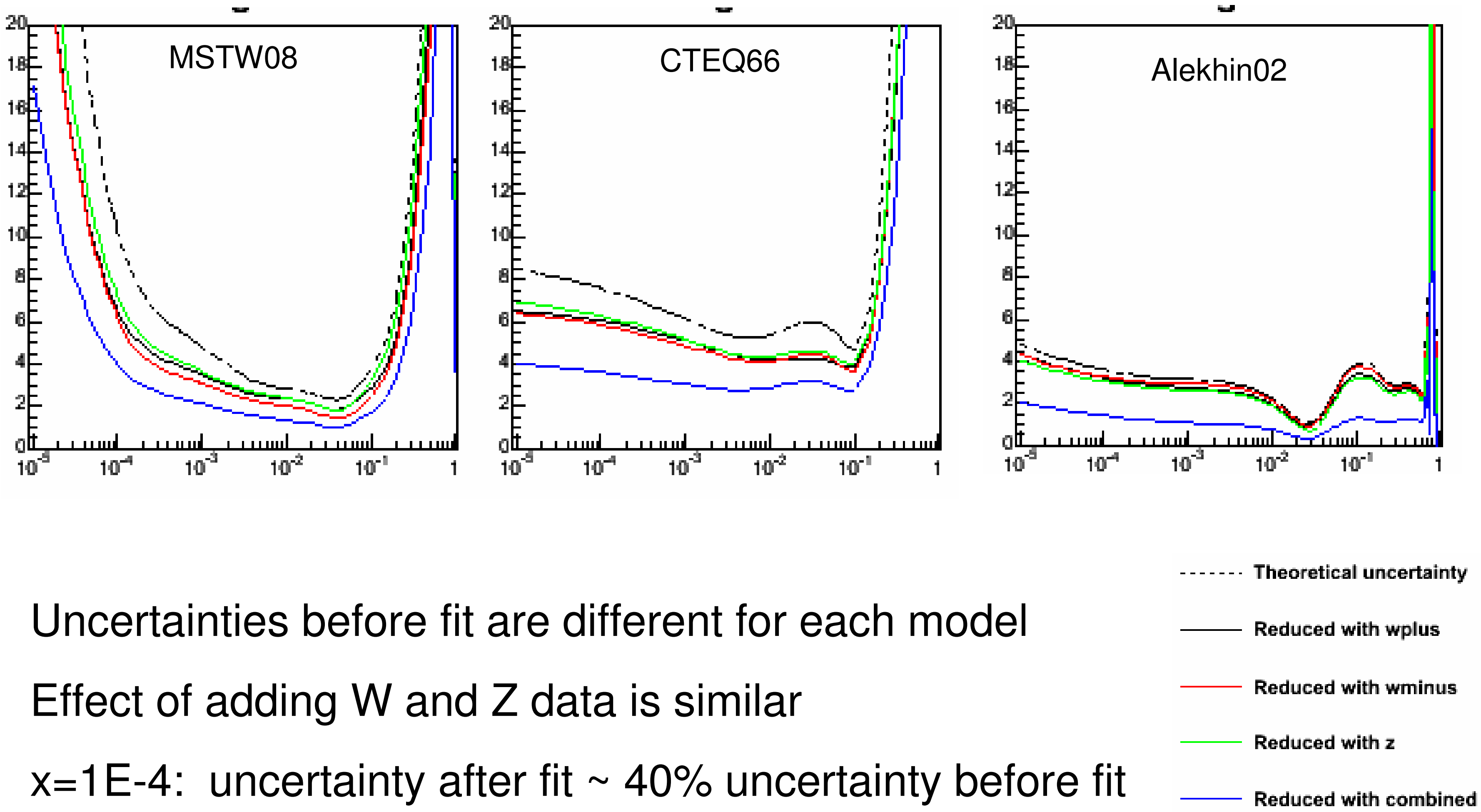
Uncertainties before fit are different for each model

Effect of adding W and Z data is similar

x=1E-4: uncertainty after fit = 2/3 uncertainty before fit



Effect on gluon PDF with fit to 10fb^{-1} of LHCb data at Q^2=100 GeV^2



Uncertainties before fit are different for each model

Effect of adding W and Z data is similar

x=1E-4: uncertainty after fit ~ 40% uncertainty before fit

10fb-1 of LHCb W&Z data => > halve uncertainty on gluon pdf

Future work

- Further cross-check with physics expectations.
- Extend fits to other PDF sets
- Fit to differential distribution for γ^*: $\frac{d^2\sigma}{dQ^2 dy}$
  (preliminary results show major improvements)