Introduction

High precision measurements of well known SM quantities can be used to test and restrict the available PDFs.

Many such analyses have already been presented:
"Recent results on (multi)-jet production measurements with the ATLAS and CMS experiments", Matthias Artur Weber
"Recent results on (associated) vector boson production with the ATLAS and CMS experiments", Sofia Chouridou

I will focus on the effect of three of these analyses on PDFs, studied using the HERAFitter.

- Inclusive jet differential cross-section
- W charge asymmetry
- W + c production

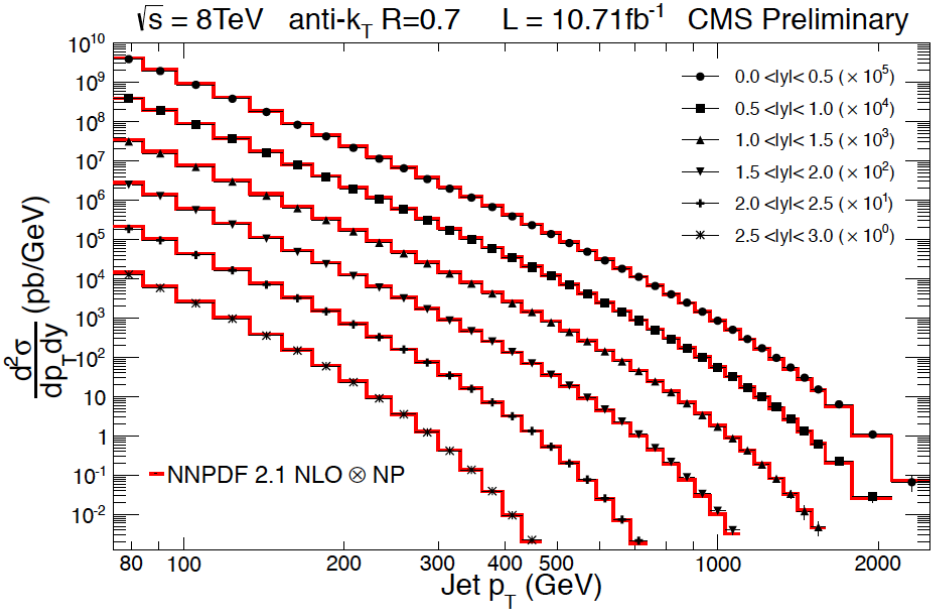
Jet inclusive cross-section

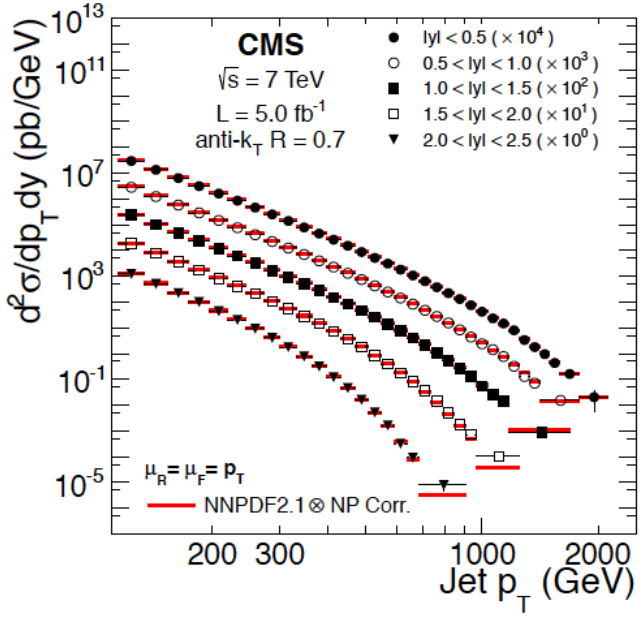
Jet production at the LHC provides a direct probe to the gluon content of the proton.

The inclusive jet differential cross-section is measured as a function of the jet p_T in different pseudo-rapidity regions.

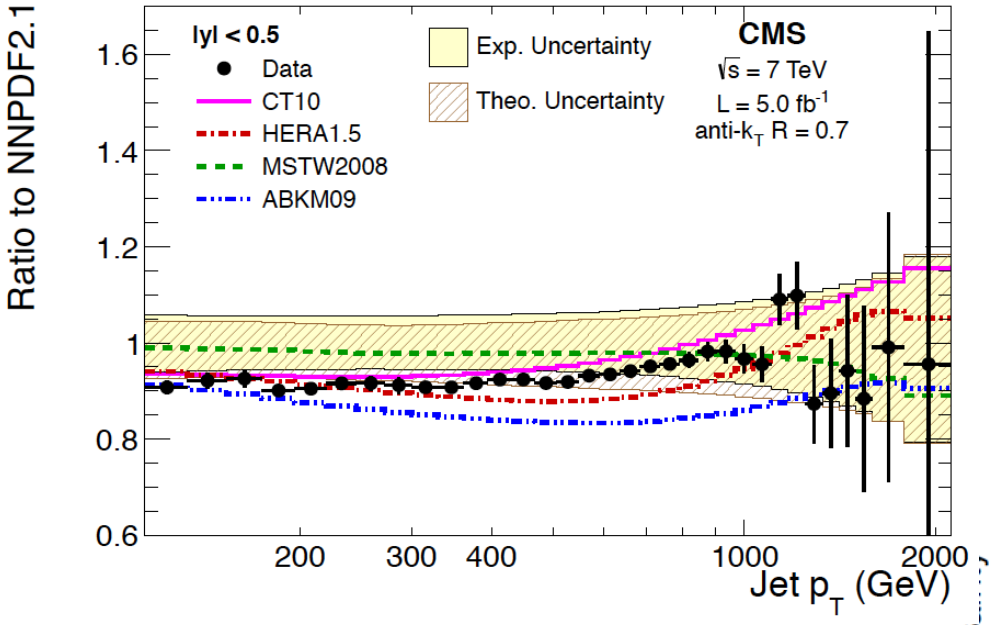
At $\sqrt{s}$ = 7 TeV on 5 fb^{-1} of data: Phys. Rev. D 87 (2013) 112002

At $\sqrt{s}$ = 8 TeV on 10.7 fb^{-1} of data: CMS-PAS-SMP-12-012





Jet inclusive cross-section

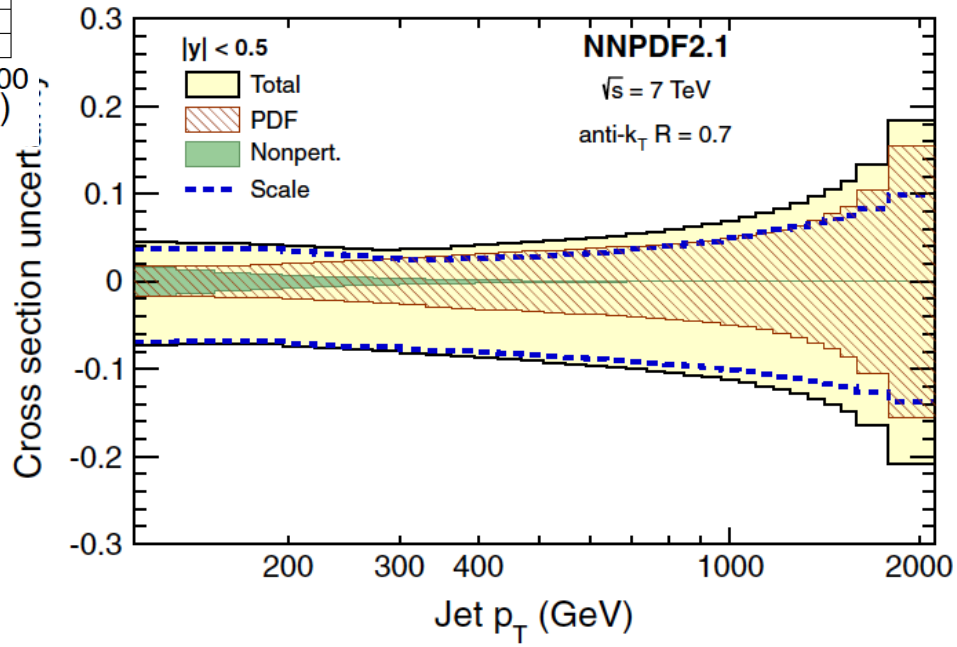


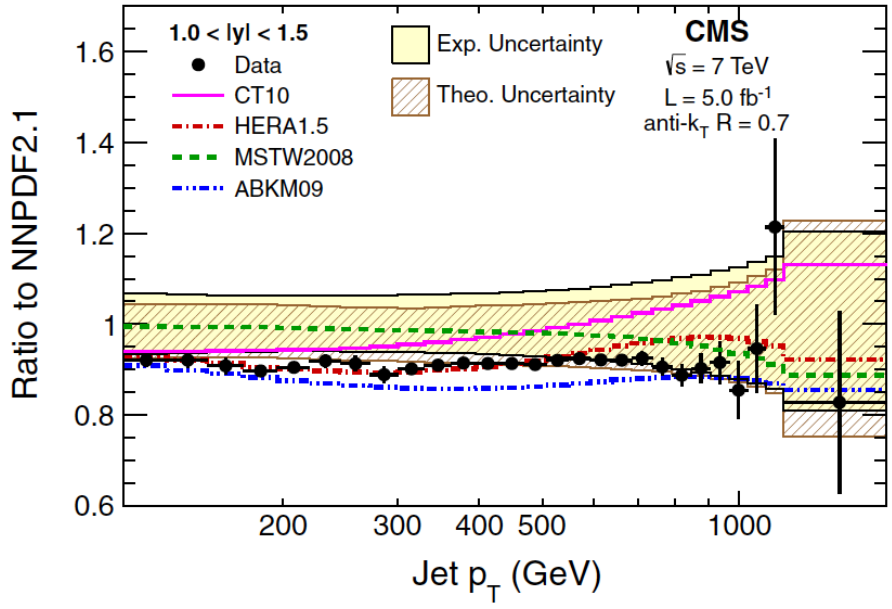
Theoretical and experimental uncertainty of similar size.

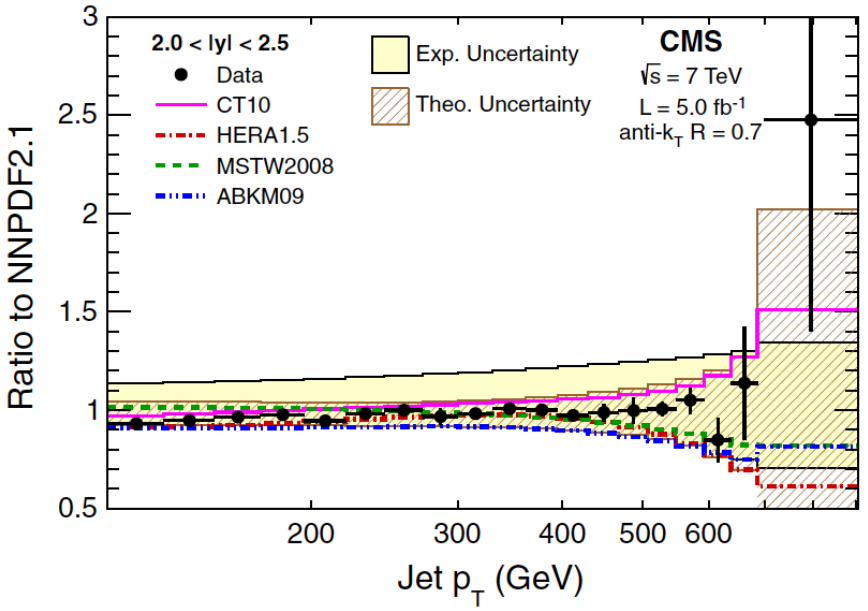
Results are compared to different PDF predictions: NNPDF2.1, CT10, MSTW2008, HERA1.5 and ABKM09.

The experimental uncertainty is dominated by the jet energy scale.

The theoretical uncertainty by PDF uncertainty and the factorization and renormalization scale




1.0 < |y| < 1.5
Data
CT10
HERA1.5
MSTW2008
ABKM09
Exp. Uncertainty
Theo. Uncertainty
CMS
√s = 7 TeV
L = 5.0 fb-1
anti-kT R = 0.7
Ratio to NNPDF2.1
Jet pT (GeV)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Data
CT10
HERA1.5
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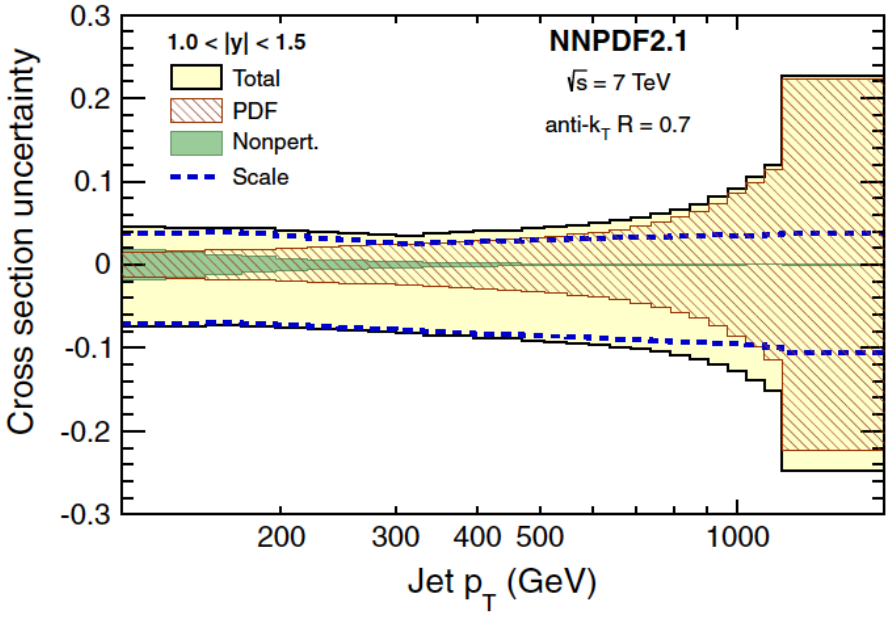
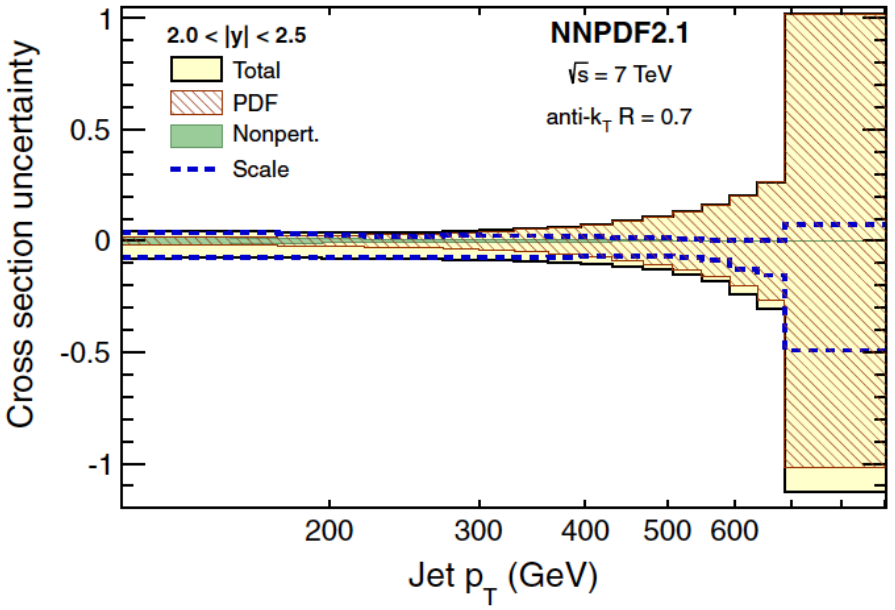

1.0 < |y| < 1.5
Total
PDF
Nonpert.
Scale
NNPDF2.1
√s = 7 TeV
anti-kT R = 0.7
Cross section uncertainty
Jet pT (GeV)


2.0 < |y| < 2.5
Total
PDF
Nonpert.
Scale
NNPDF2.1
√s = 7 TeV
anti-kT R = 0.7
Cross section uncertainty
Jet pT (GeV)

HERAFitter

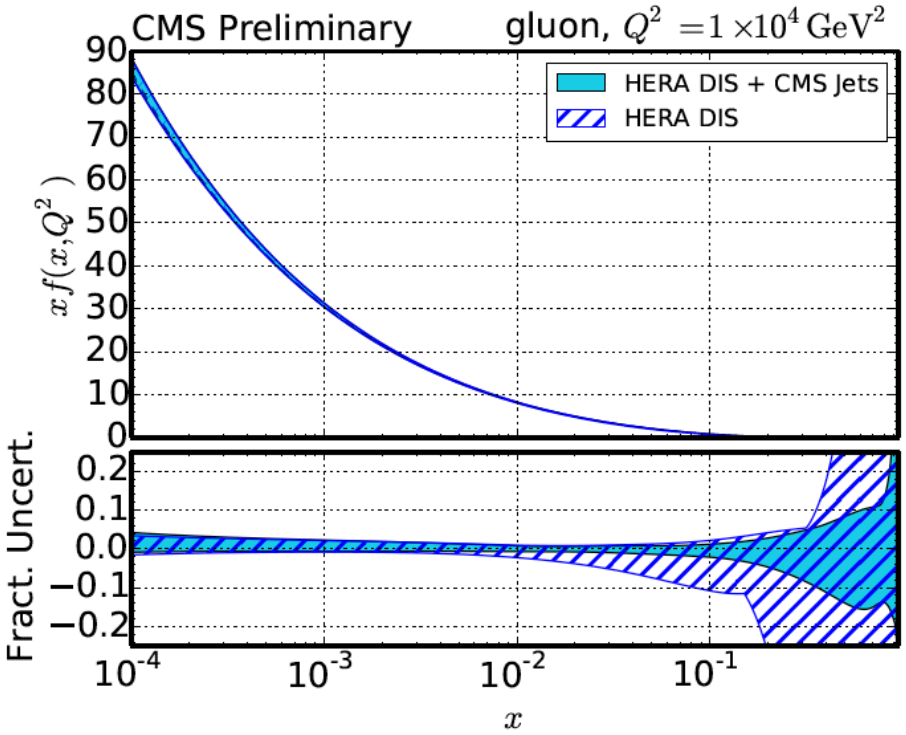
The effect of the $\sqrt{s}$ = 7 TeV measurement on PDFs is studied using the HERAFitter. CMS-PAS-SMP-12-028

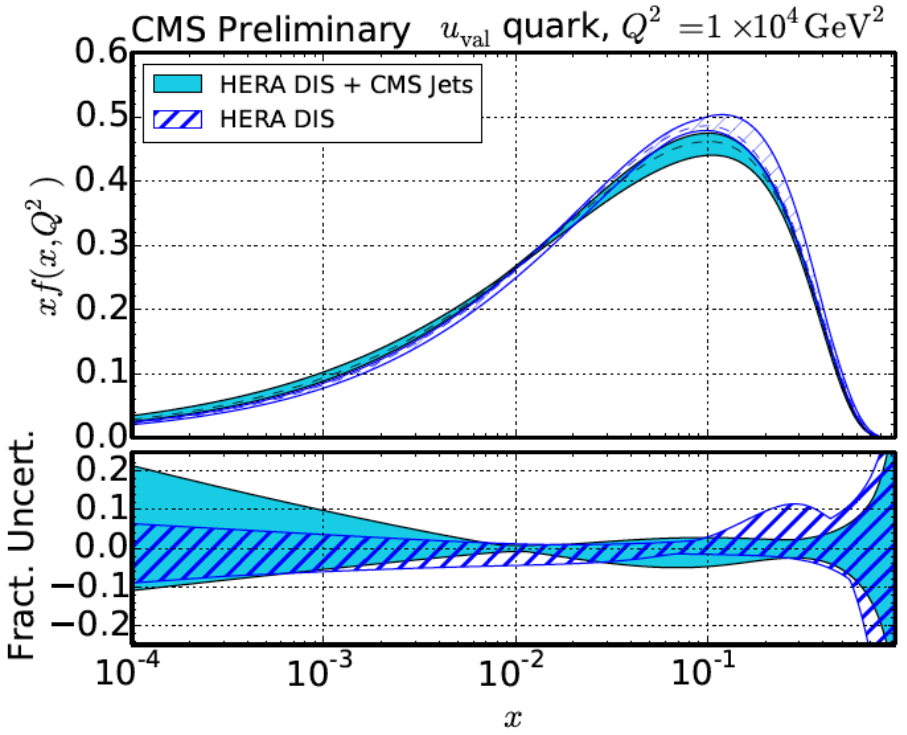
Five independent PDFs are assumed:
gluon, $u_{valance}$, $d_{valance}$, $\bar{u}_{sea}$ and the linear combination of $\bar{d}_{sea} + \bar{s}_{sea}$.
The strange fraction is fixed to 0.31 ± 0.07.
$\alpha_s(M_Z) = 0.1176$

Using the default parameterization of the HERAFitter leads to 13 free parameters. Which are fitted to HERA DIS data and the CMS inclusive jet double-differential cross-section.

Three types of uncertainties are considered:
Experimental: taking into account the correlations between results
Model: varying the strange fraction, the b-quark mass, the choice of included DIS data
Parameterization: adding additional terms to the five independent PDFs

Jet inclusive cross-section



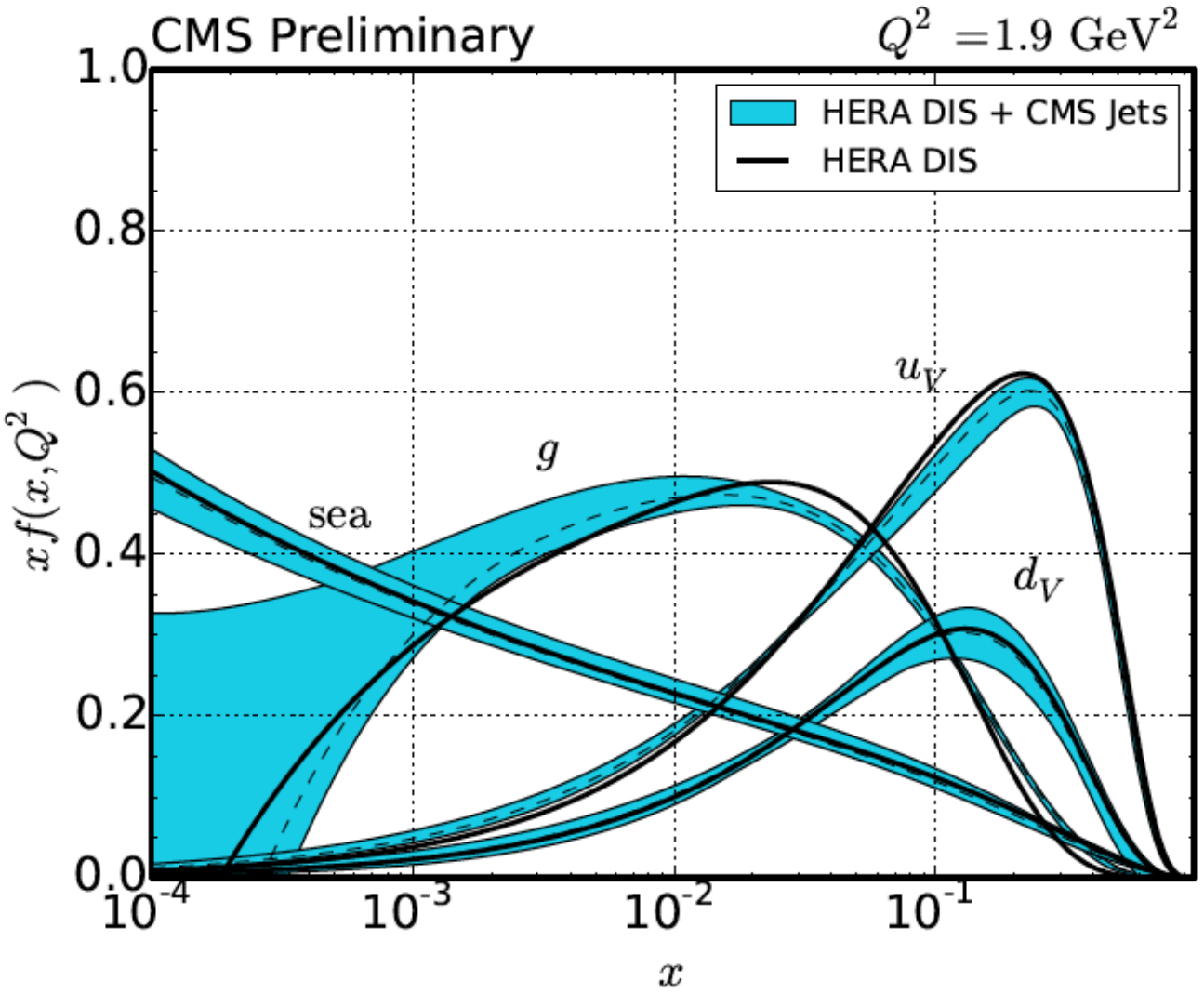


The CMS jet data significantly reduces the uncertainty in the gluon PDFs for x > 0.01

The CMS jet data, especially in the forward region also helps reduce the uncertainty in the u valence quark PDF for x > 0.3

The effect of the CMS jet data should be less pronounced on PDF sets trained on a combination of Tevatron and HERA data.

Jet inclusive cross-section



W-boson charge asymmetry

W-bosons at the LHC are produced through the annihilation processes: $u\bar{d} \rightarrow W^+$ and $d\bar{u} \rightarrow W^-$. Involving a valence quark (u or d) and a sea antiquark.

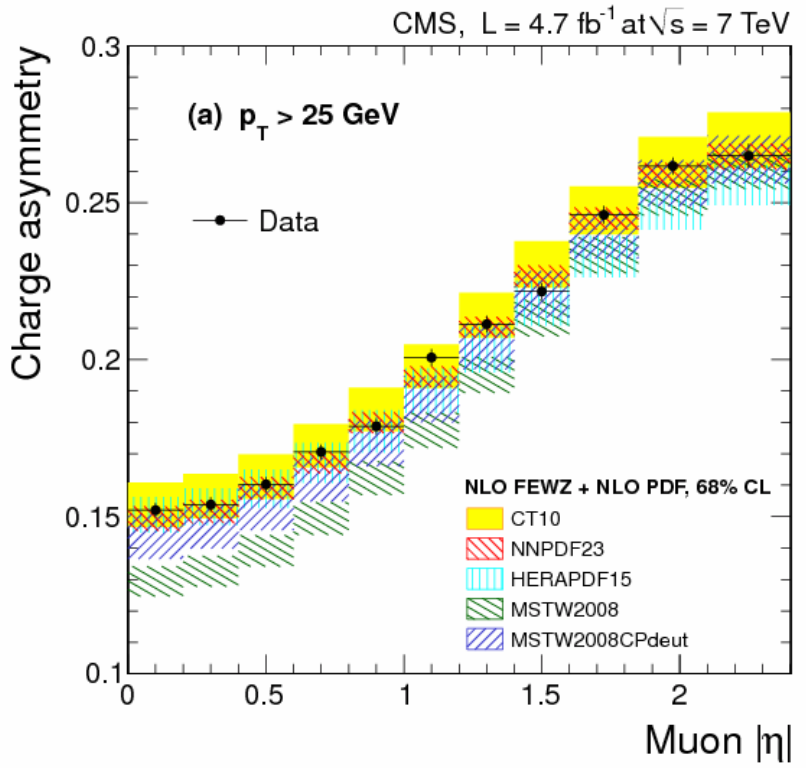
The W-boson production charge asymmetry can help constrain the d/u ratio and sea antiquark PDFs.

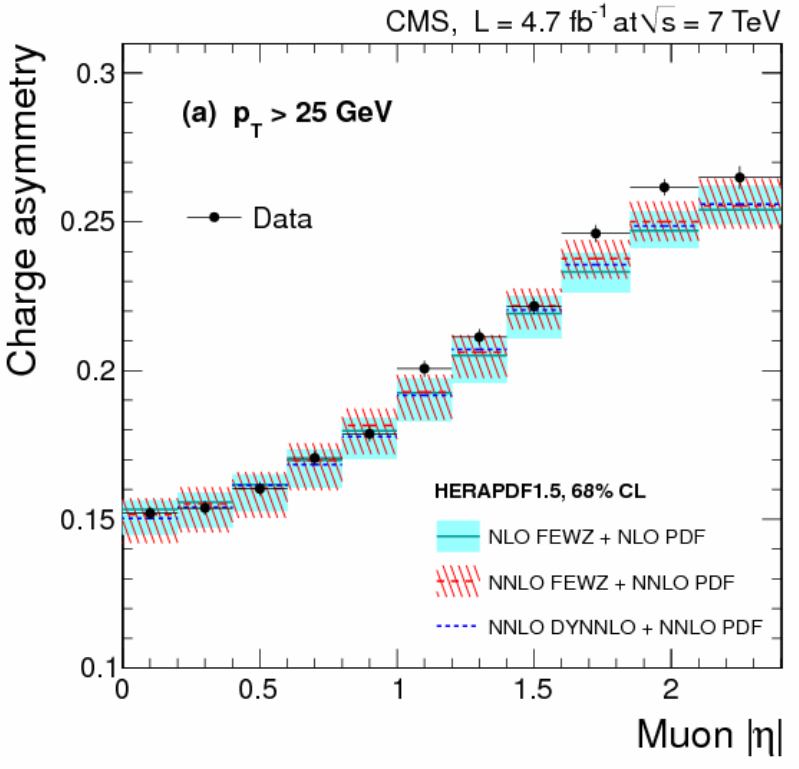
The W-boson muon charge asymmetry is measured as a function of muon pseudo-rapidity:

$$\mathcal{A}(\eta) = \frac{\frac{d\sigma}{d\eta}(W^+ \rightarrow \ell^+\nu) - \frac{d\sigma}{d\eta}(W^- \rightarrow \ell^-\bar{\nu})}{\frac{d\sigma}{d\eta}(W^+ \rightarrow \ell^+\nu) + \frac{d\sigma}{d\eta}(W^- \rightarrow \ell^-\bar{\nu})}$$

Performed at $\sqrt{s}$ = 7 TeV on 4.7 fb^{-1} of data: PRD 90 (2014) 032004

W-boson charge asymmetry



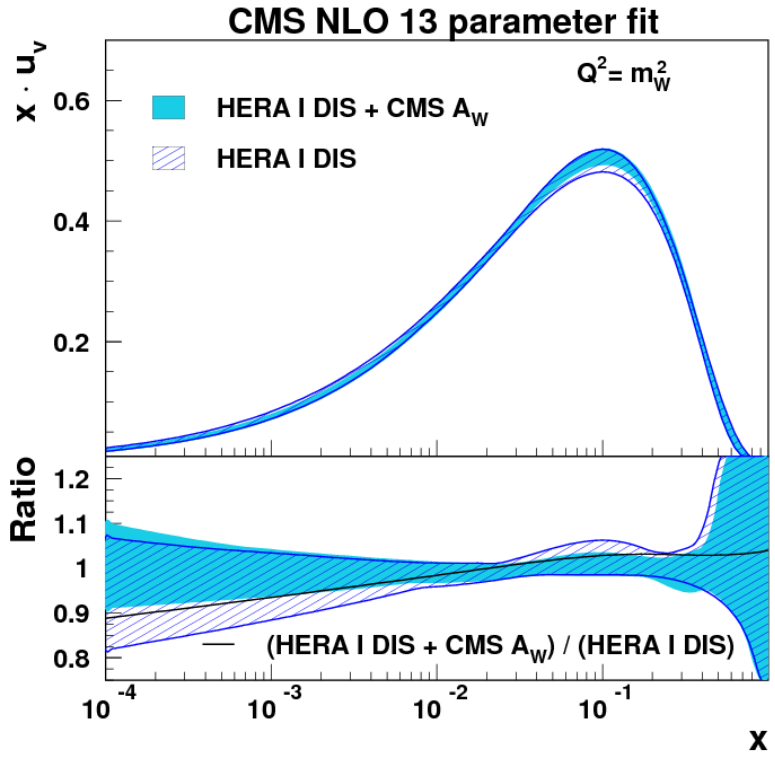


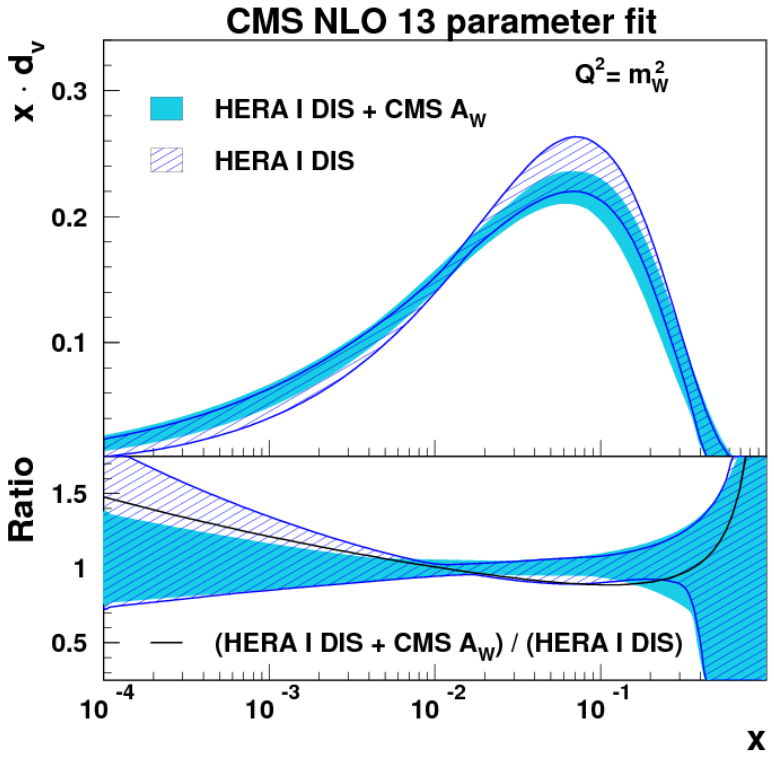
The measured W-boson muon charge asymmetry is compared with predictions using different PDF sets. Largest discrepancy is seen with MSTW2008 however the more recent and flexible MSTW2008CPdeut PDF set shows better agreement.

W-boson charge asymmetry

The effect of the W-boson charge asymmetry measurement is evaluated using the HERAFitter.

The largest effect is on the $u_{valance}$ and $d_{valance}$ PDFs ($0.001 < x < 0.1$).

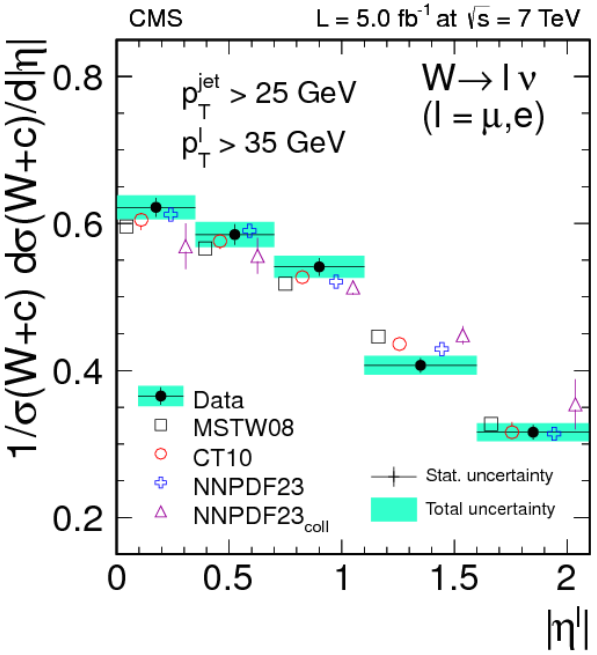


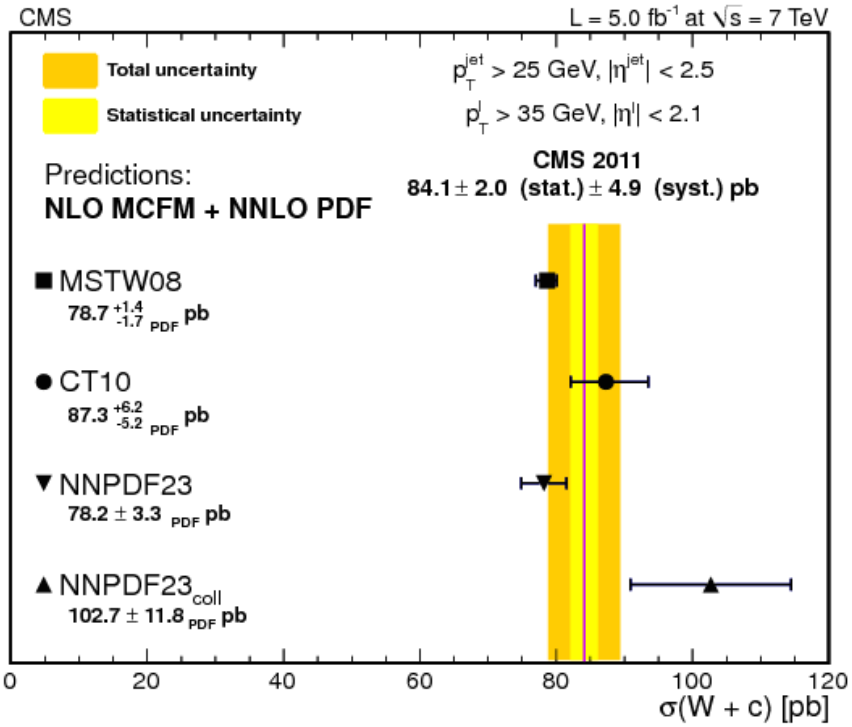


W-boson + c production

The W-boson + c production depends on the strange PDF. The W-boson charge asymmetry in these events probes the ratio between the strange quark and anti-quark PDFs.

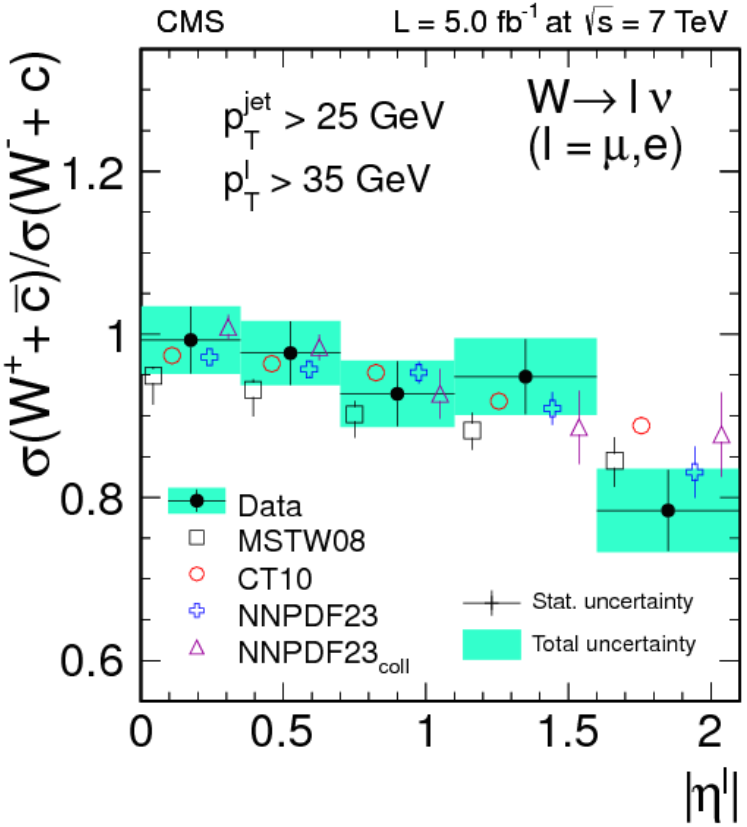
W-boson + c events have been studied at $\sqrt{s}$ = 7 TeV on 5 fb^{-1} of data:
JHEP 02 (2014) 013

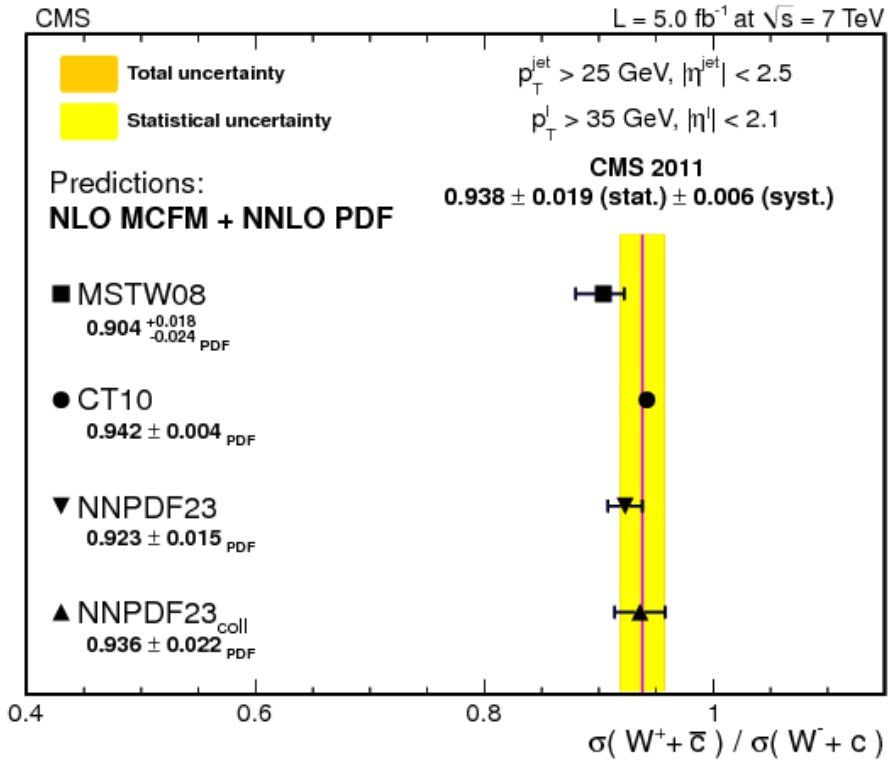




W-boson + c production

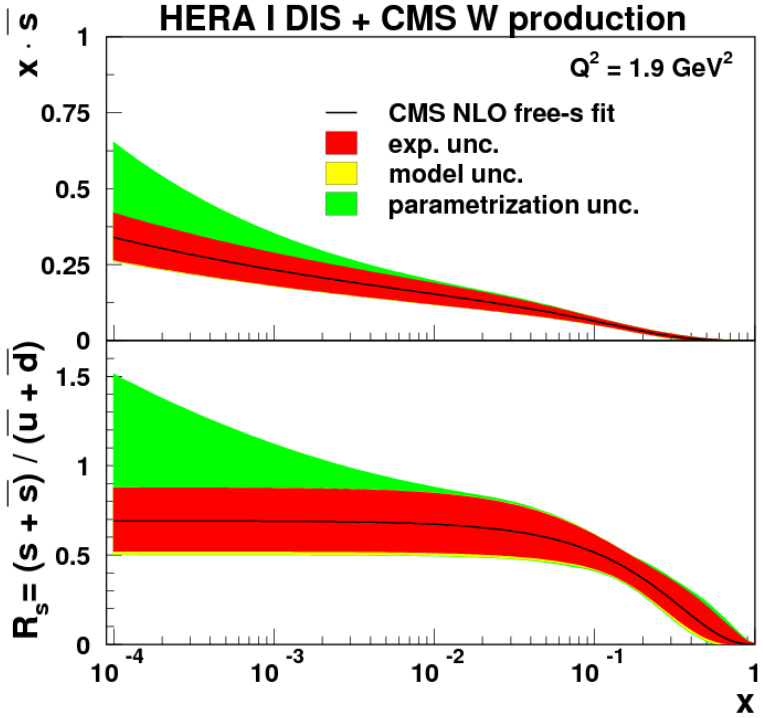
$$R_c^{\pm} = \frac{\sigma(W^+ + \bar{c})}{\sigma(W^- + c)} = \frac{(N_{sel}^+ - N_{bkg}^+)}{(N_{sel}^- - N_{bkg}^-)}$$

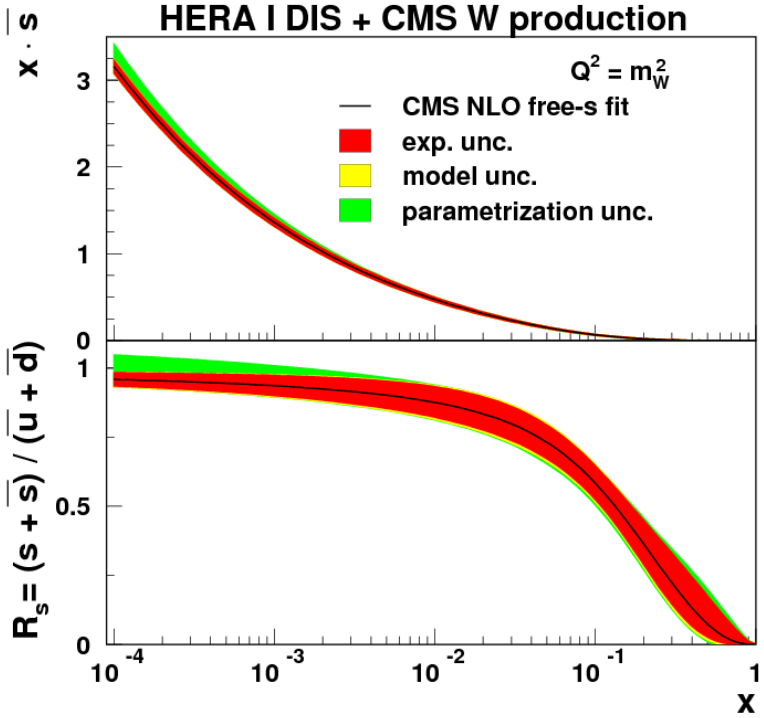




W-boson + c production

Adding the W-boson + c measurements and the W-boson muon charge asymmetry to the HERAFitter, allows the introduction of an independent anti-strange PDF. Resulting in 15 free parameters.





Conclusion

A wide range of CMS results are sensitive to the PDF shapes.

Jet studies, such as the inclusive jet differential cross-section presented here, can help reduce the gluon PDF uncertainties at large x, and to a lesser extend the $u_{valance}$ and $d_{valence}$ PDFs.

SM gauge boson productions can probe the $u_{valance}$, $d_{valence}$,$\bar{u}_{sea}$ and $\bar{d}_{sea}$ PDFs. When produced in combination with a c and/or b quark, the heavier quark PDFs can be accessed.

For a full set of the available CMS results, please visit:
http://cms.web.cern.ch/org/cms-papers-and-results