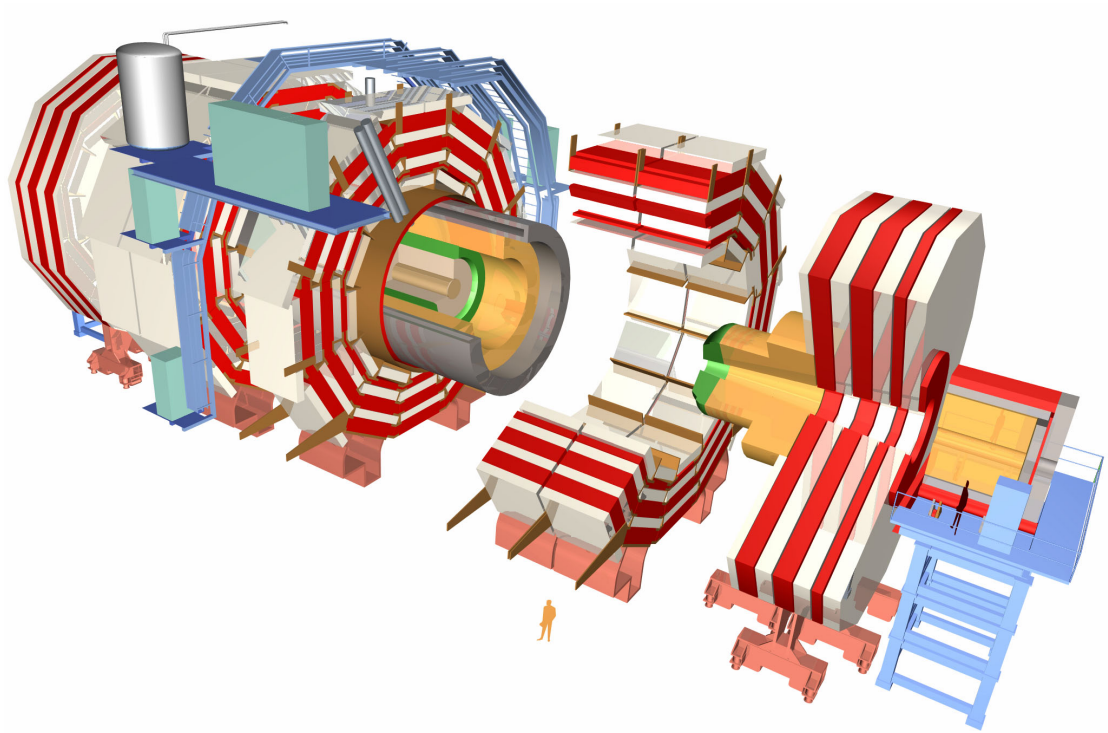
CMS PDF Results



Matthias Weber (UCLA)

on behalf of the CMS collaboration

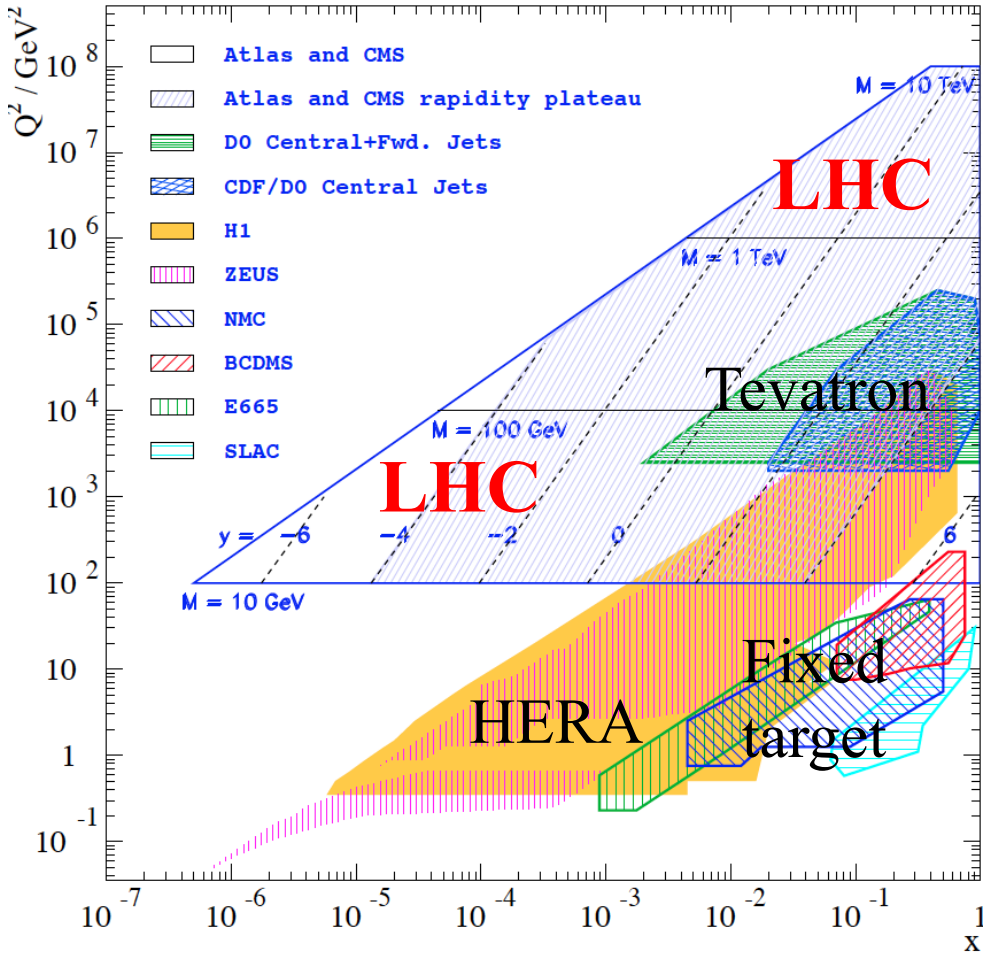
PDF sensitivity at the LHC

PDFs determined through global fits to many observables

- High precision on PDF's allows for more accurate extraction of theory parameters

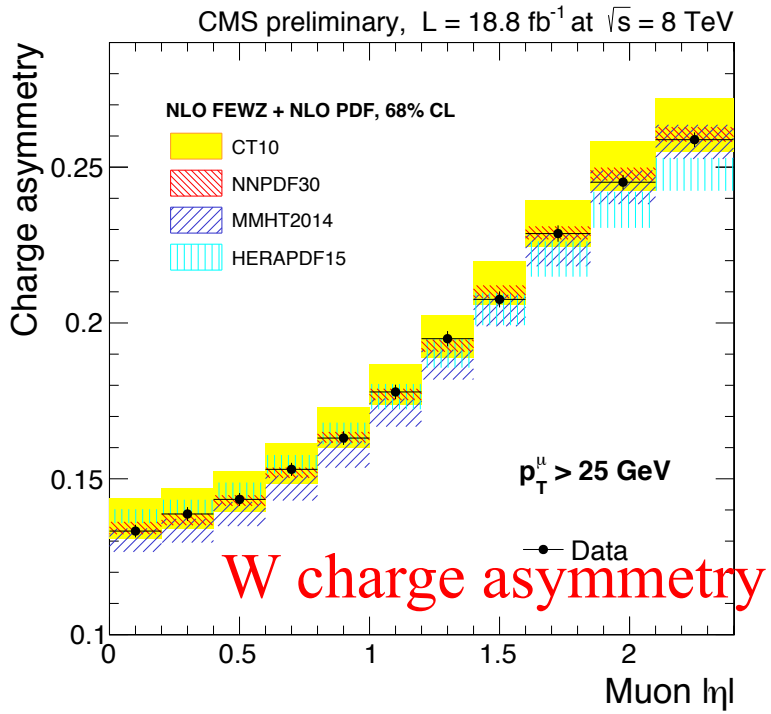
LHC data provides huge amount of data in unexplored kinematic regions

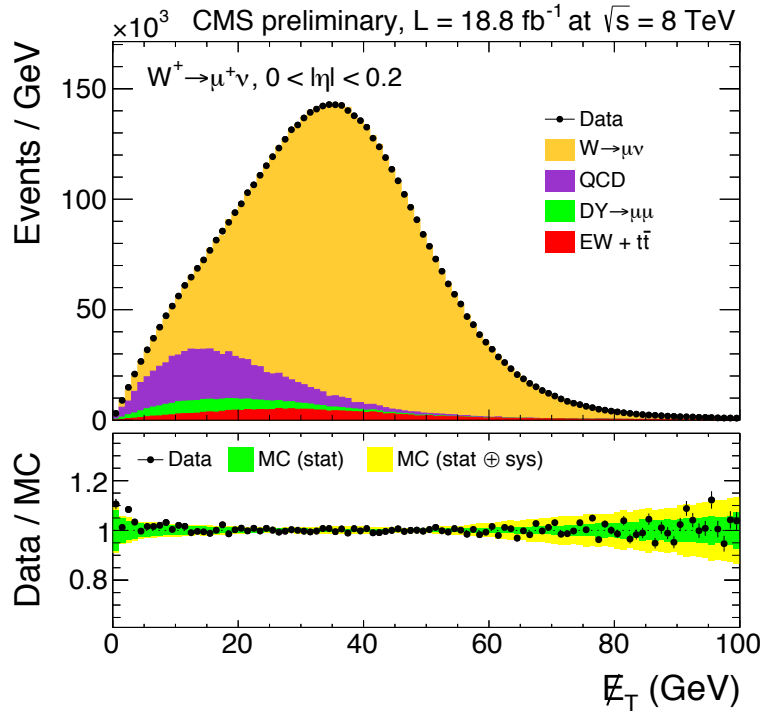
- Provide constraints on PDF in vastly unchartered space
- Largest reach in momentum scale Q^2 beyond the TeV range (using DGLAP evolution)
- Reach to very low momentum fraction x (10^{-5})



S. Glazov, Braz.J.Ph. 37 (2007) 793

W differential charge asymmetry at 8 TeV



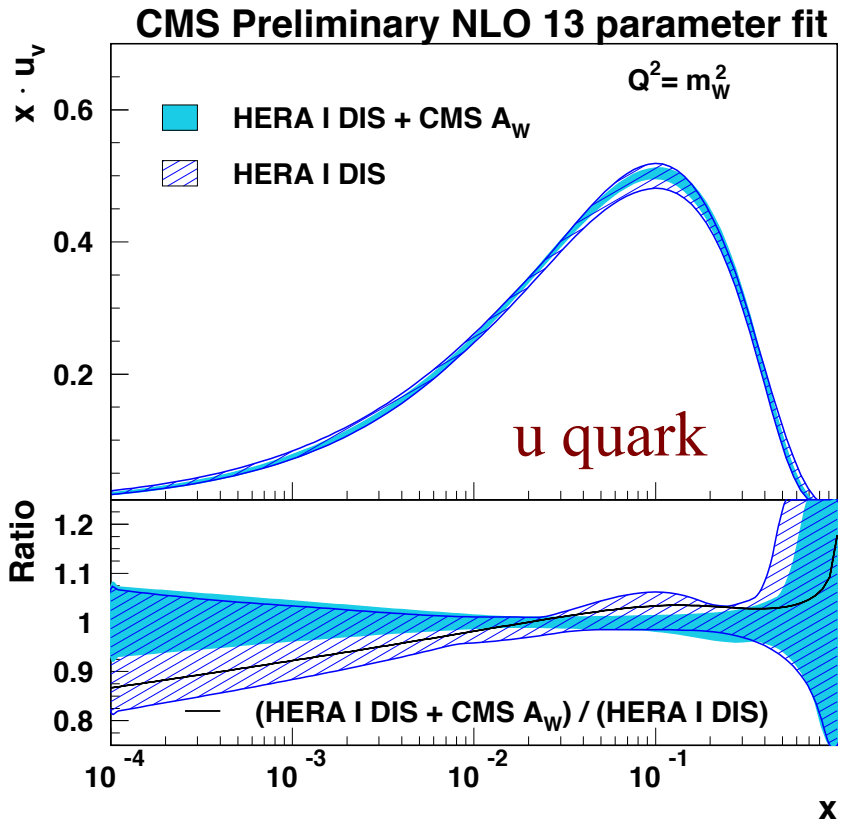


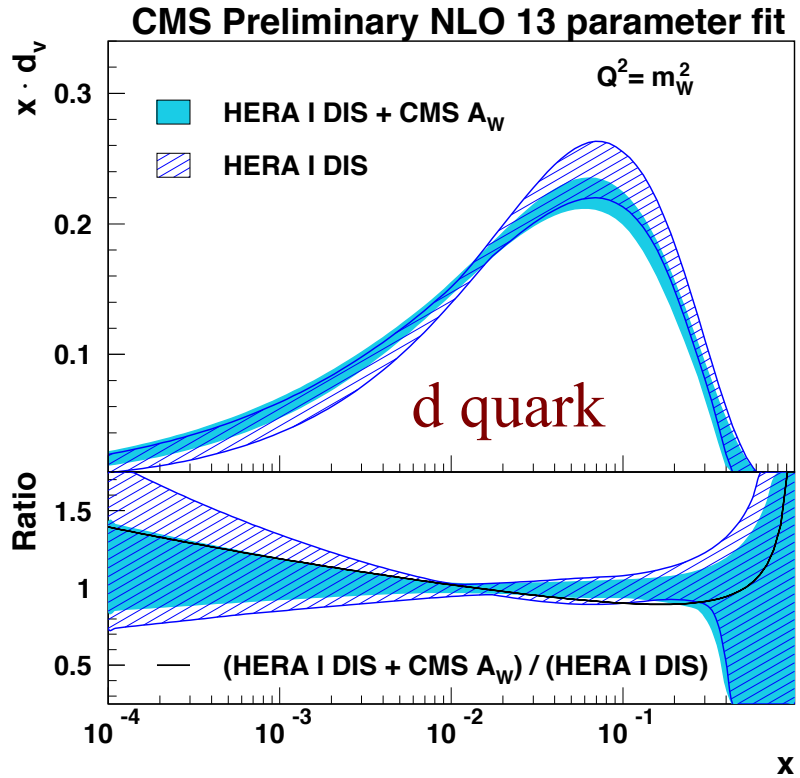
Charge asymmetry

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

W signal yield determined through fitting the missing transverse energy.
QCD templates constrained in control region inverting the isolation criteria on muons

W charge asymmetry: quark PDF fits

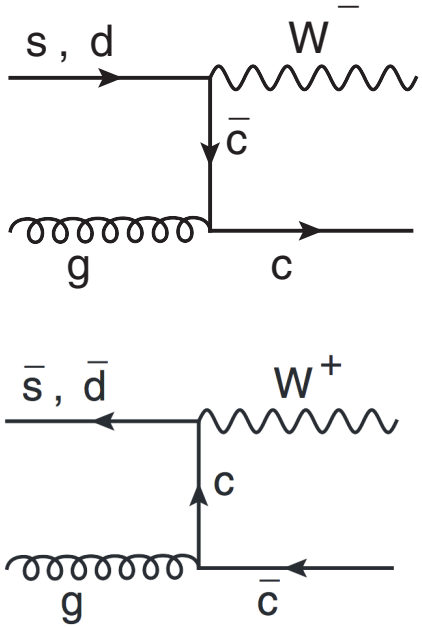


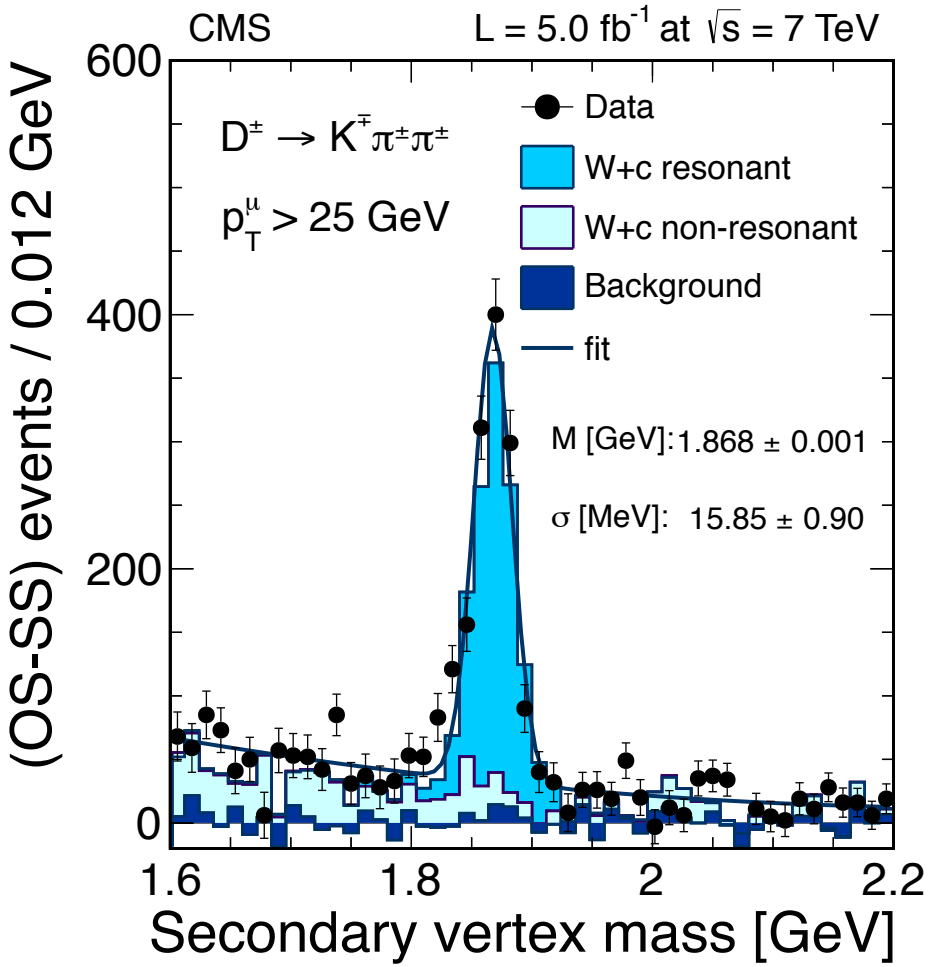


Extraction of valance u and d quark PDF: reducing the uncertainties by up to 50 % and sizable change of PDF's especially for d quark

W + charm at 7 TeV

Measurement of W + charm gives access to strange quark PDF and its asymmetry



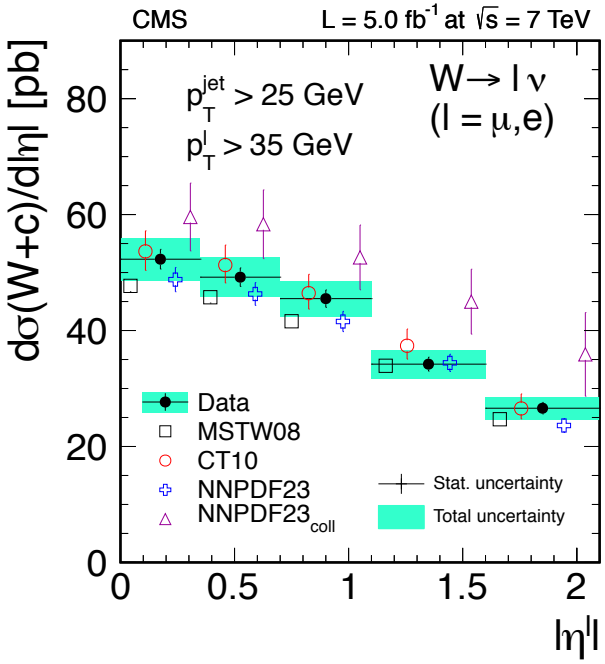


Charm jets identified through displaced secondary vertices consistent with D meson decays (e.g. $D^+ \rightarrow K^-\pi^+\pi^-$)

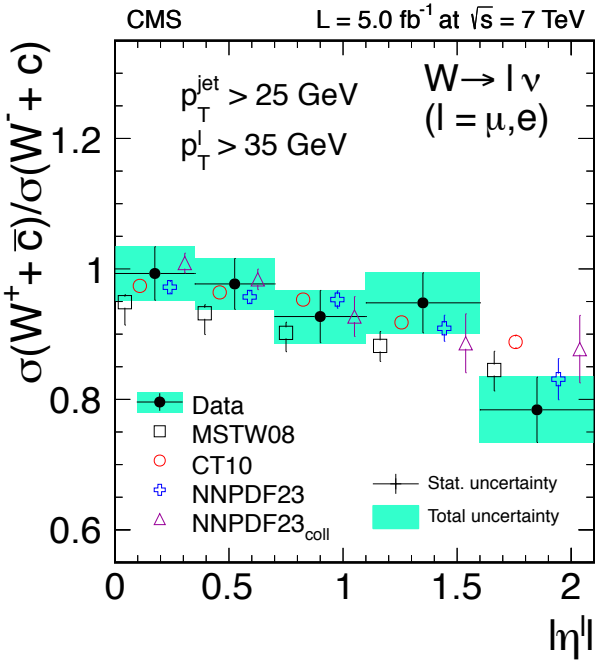
JHEP 02 (2014) 013

W + charm differential cross-section at 7 TeV

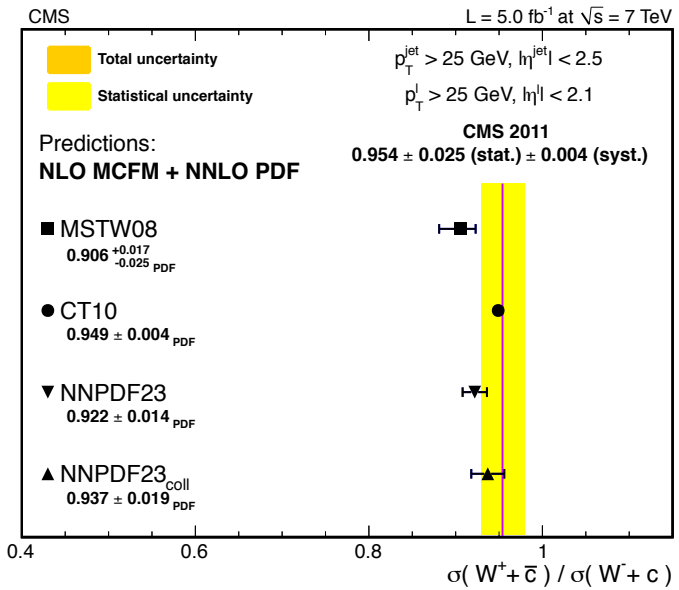
cross-section and cross-section asymmetry as function of lepton pseudorapidity



cross-section



Cross-section asymmetry

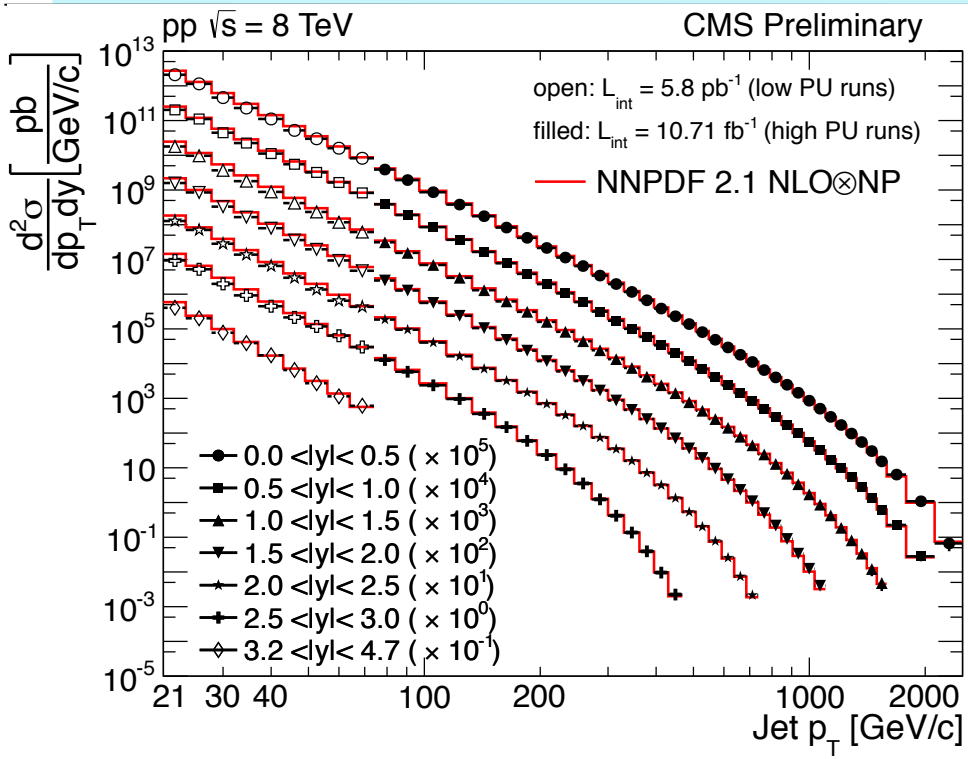


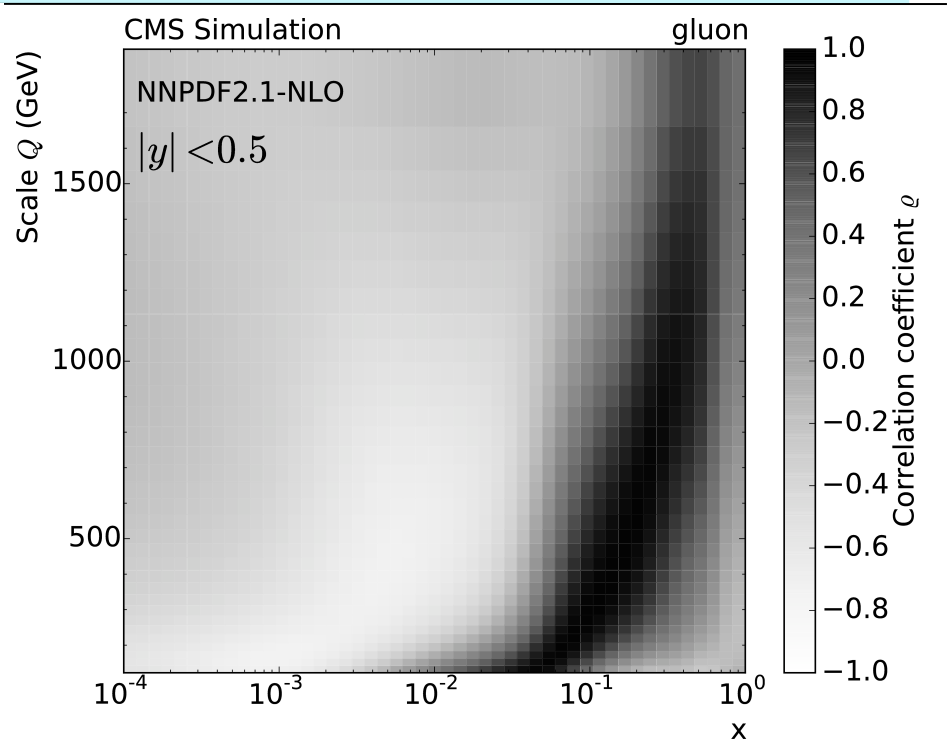
Total cross-section asymmetry

Comparions to MSTW08, CT10, NNPDF23 and NNPDF23$_{coll}$ (collider data only) PDFs

JHEP 02 (2014) 013

Inclusive jet cross-section measurements





CMS simulation at 7 TeV

Inclusive jet p_T cross-section at 8 TeV in 7 rapidity bins from 20 to 2500 GeV, over 15 orders of magnitude. Dedicated low pile-up runs for precise measurement at low p_T

➡ large correlation between gluon PDF and inclusive cross-section measurement

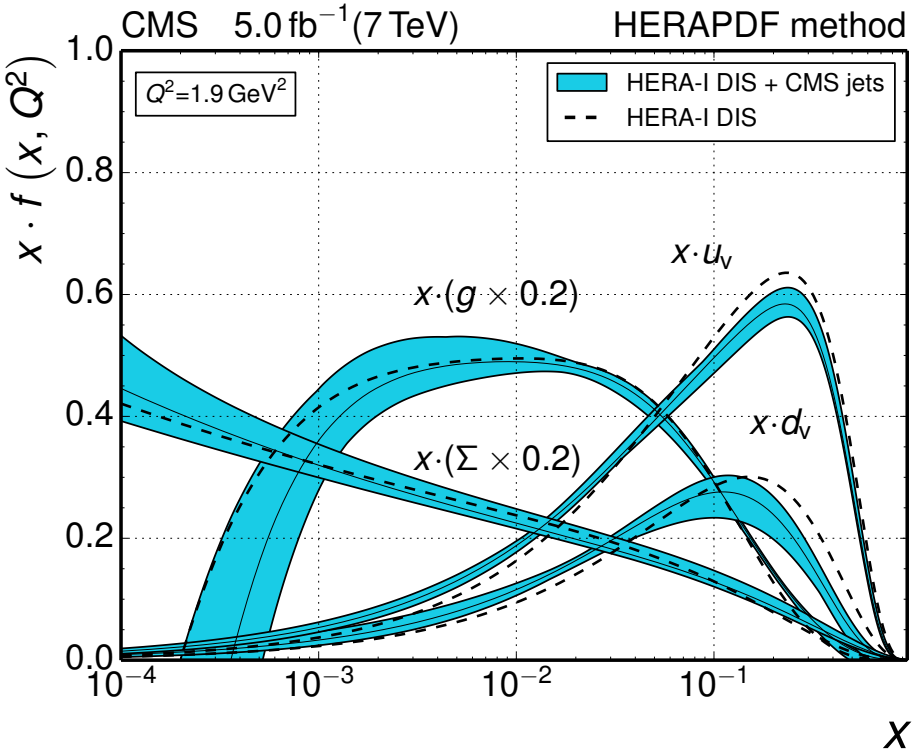
CMS-PAS-SMP-12-012

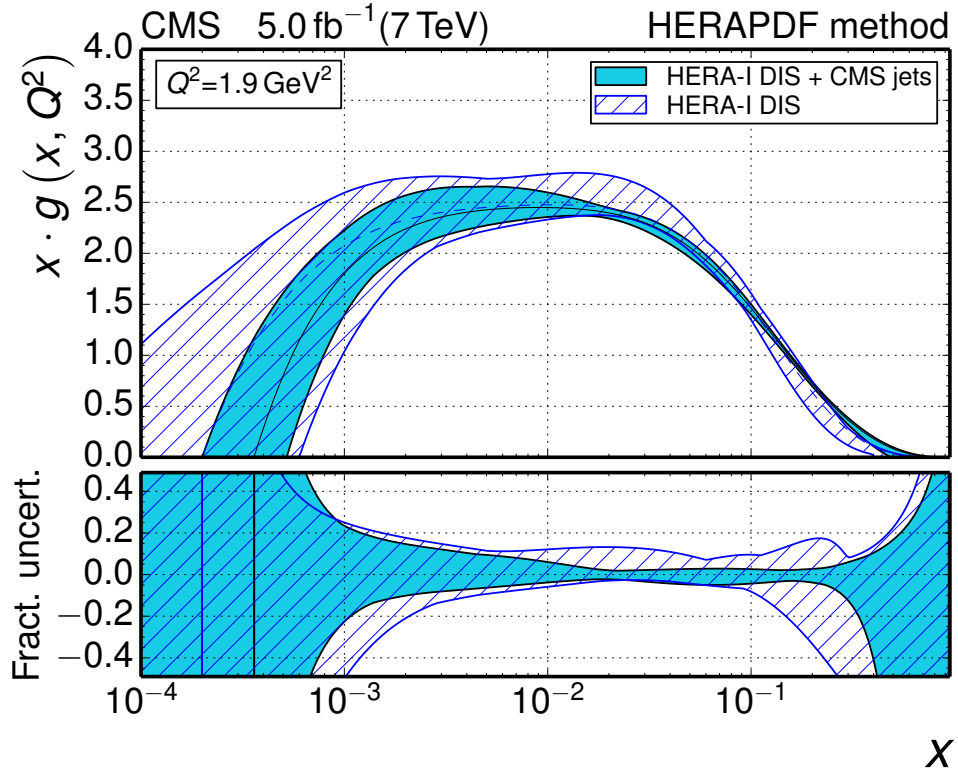
CMS-PAS-FSQ-12-031

EPJC 75 (2015) 288

PDF extraction using CMS jet data at 7 TeV

Measurement of inclusive jet p_T spectrum particularly sensitive to gluon PDF
Jets observed beyond the TeV range





First extraction of gluon and quark PDFs using CMS jet data at 7 TeV with most significant improvement of the gluon PDF at high x

PDF uncertainties: alternative MC method

Evaluate PDF uncertainties using a MC method similar to NNPDF procedure:

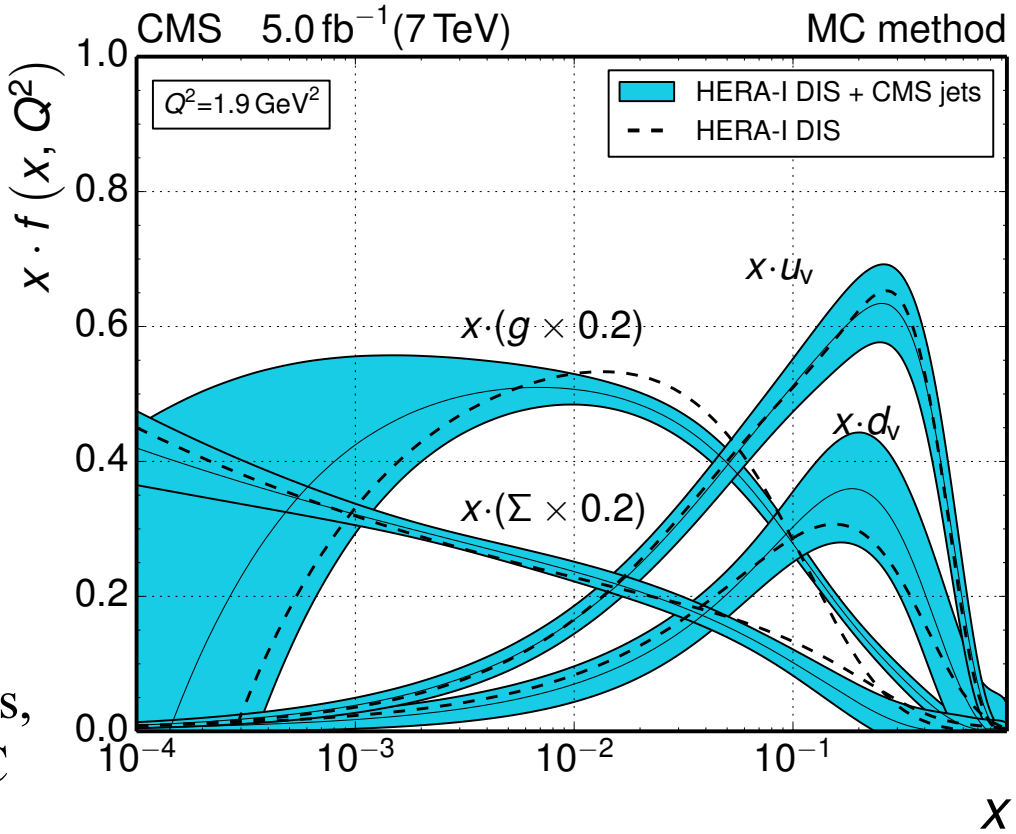
- Vary input data within correlated uncertainties
- Data-based regularization to avoid fitting of statistical fluctuations in data

Create several hundreds of replica sets through fluctuating central cross-section values within statistical and systematic uncertainties (with correlations)

- fit PDFs for each replica

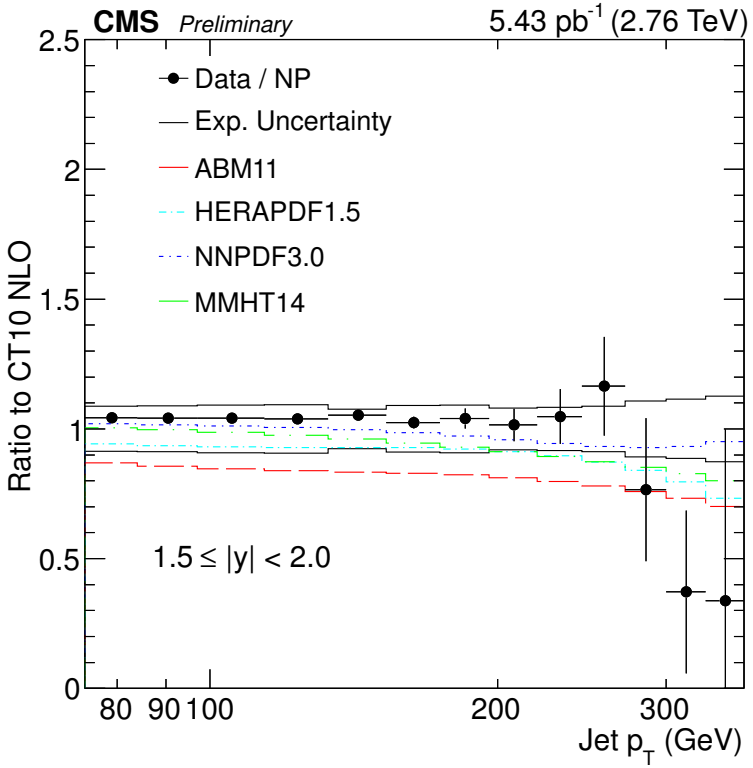
➡ Procedure provides ensemble average and RMS

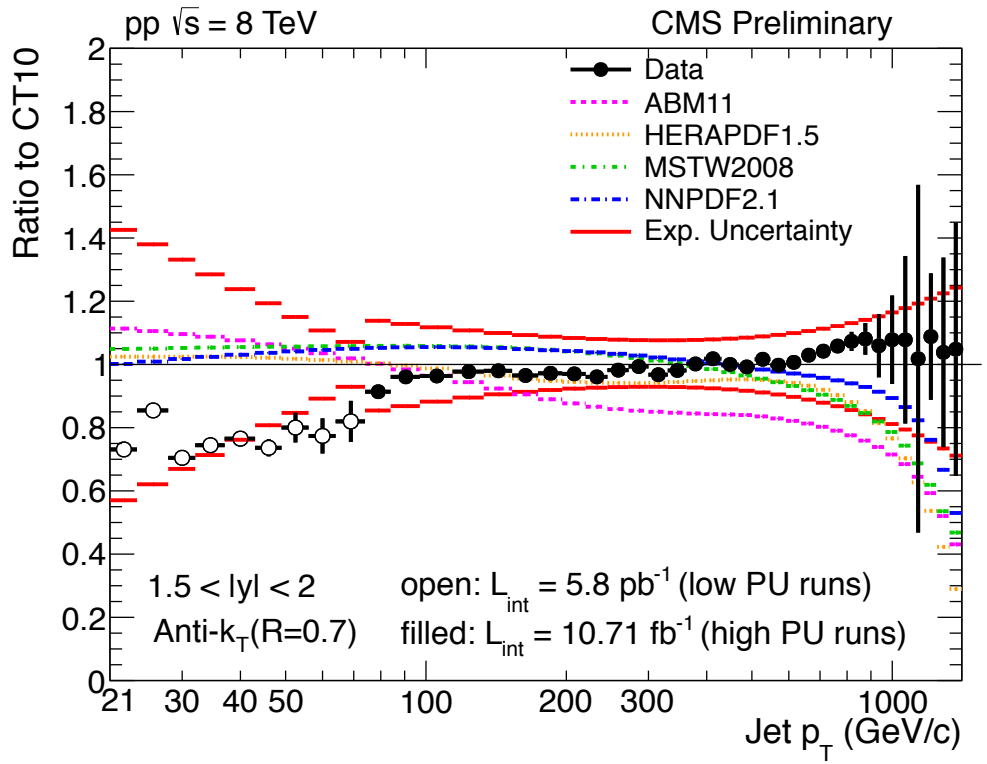
→ results compatible with default HERAPDF technique within uncertainties, typically larger total uncertainty with MC method



EPJC 75 (2015) 288

Inclusive jet cross-section at 2.76 and 8 TeV





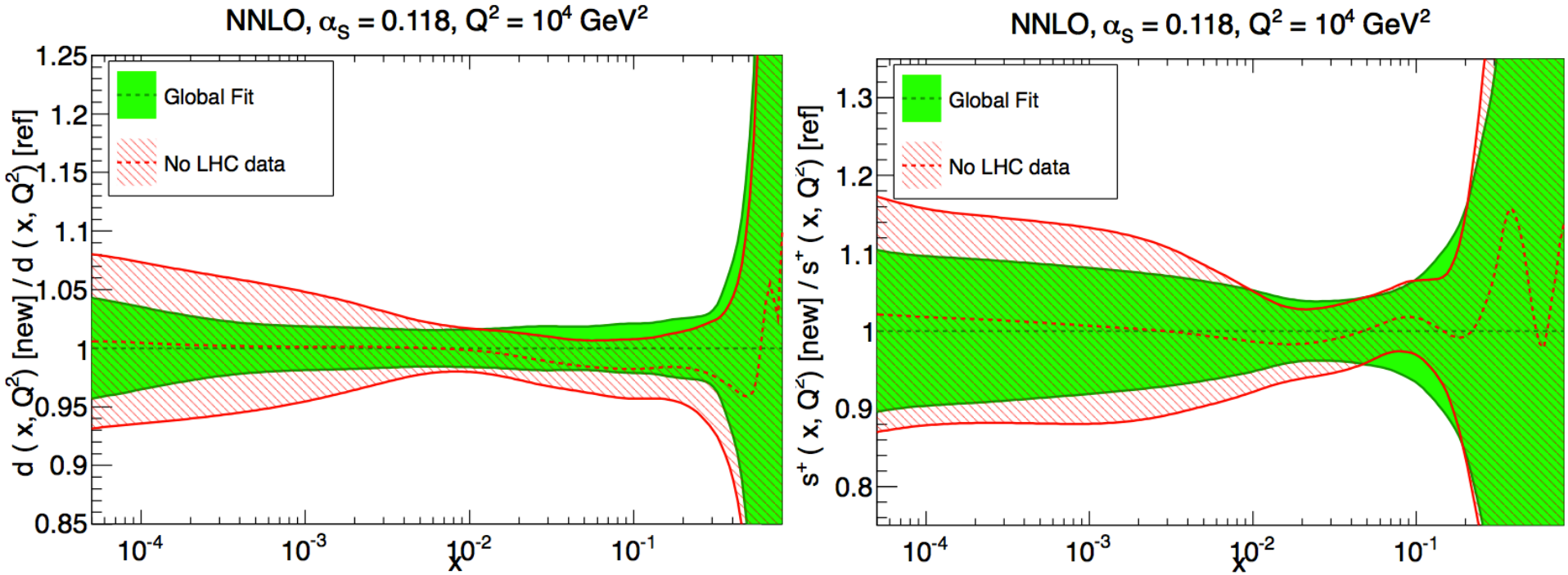
CMS results at 2.76 and 8 TeV provide new input data for PDF fits, including the ratio between both cross-section measurements

➡ provide further constraints on PDFs, especially for gluons

CMS-PAS-SMP-14-017 10 **CMS-PAS-FSQ-12-031**

Global fits including LHC data: example NNPDF

Global fits include in addition results on ttbar cross-section and double differential Drell-Yan measurements



Impact of LHC data on global fits of d and sbar quark PDFs from NNPDF 3.0: large reduction of uncertainties over large x-range

Summary

CMS data provides several analyses used in new global PDF fits of CT14, NNPDF3.0 and MMHT14 produced for RunII measurements

- Measurements of vector bosons impact mainly valence quark distributions (u, d)
  - W+charm provides additional handle on strange quark content and asymmetry between s and sbar
- Inclusive jet distributions impact new fits of gluon PDF with large reduction of uncertainties at high x
  - Help reducing uncertainties on signal production cross-sections of gluon induced processes (e.g. on $H \rightarrow \gamma\gamma$ production cross-section)
- Expect several measurements at 13 TeV extending the kinematic reach of present measurements. Finalizing 8 TeV analyses will in addition provide further constraint beyond existing new global fits used at Run II startup

BACKUP

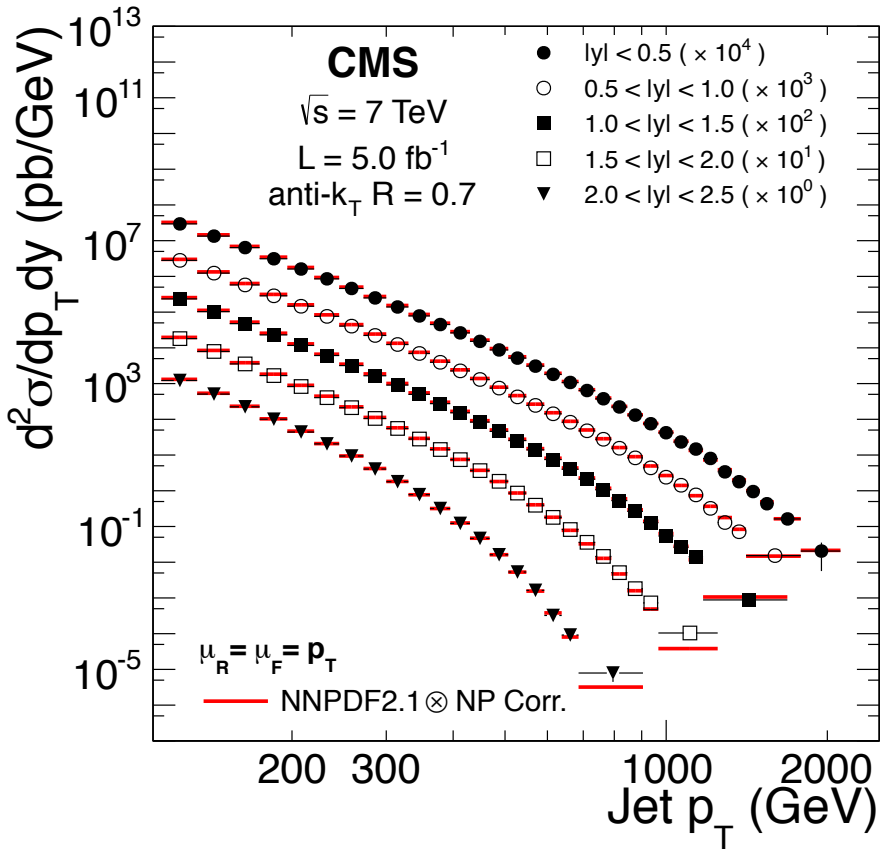
Regularization method in MC method

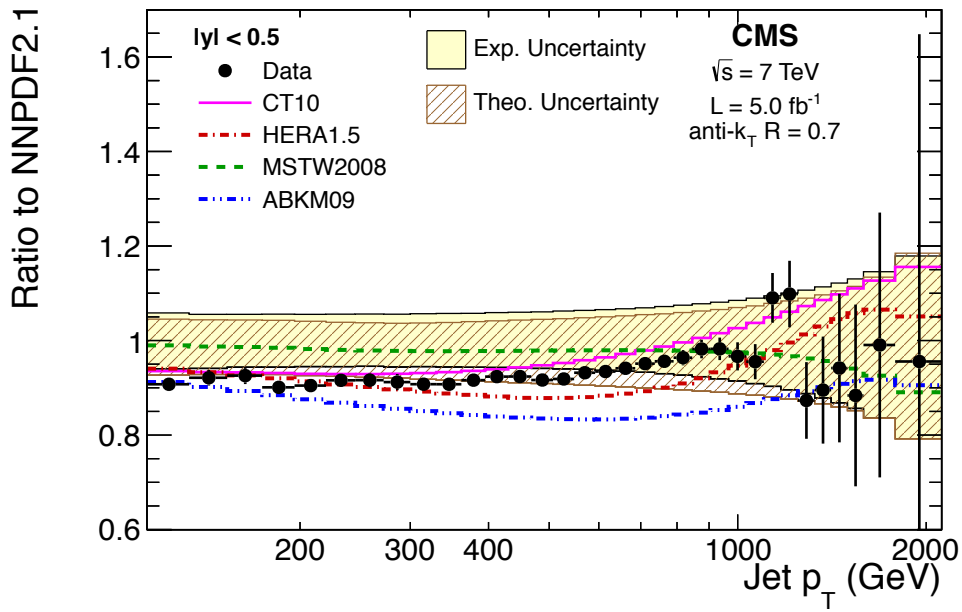
Split dataset into two halfs, the "fit" and the "control" half:

- Minimize χ^2 using the "fit" half and calculate χ^2 of control sample using candidate PDF parameters
- Use candidate PDF parameters where χ^2 of control sample of the control sample reaches its minimum

→ Procedure helps to avoid fitting of statistical fluctuations present in input dataset

CMS inclusive p_T spectrum at 7 TeV

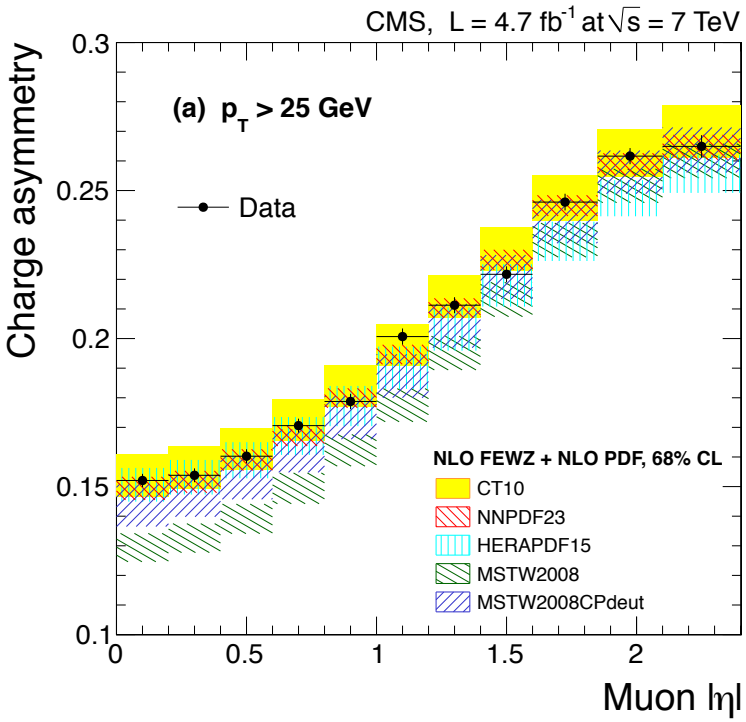


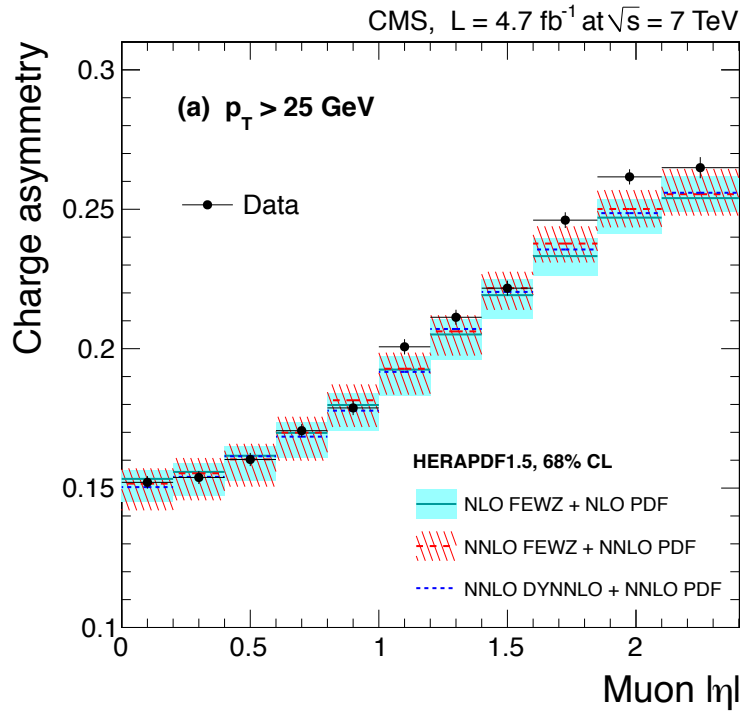


Measurement reaches from 100 GeV up to 2 TeV in 5 rapidity bins up to pseudorapidity of 2.5

PRD 87 (2013) 112002

W differential charge asymmetry at 7 TeV





The large difference between MSTW2008 and MSTW2008CPdeut is based on a more flexible input parametrization and deuteron corrections

NLO and NNLO prediction provide compatible results

PRD 90 (2014) 032004