

# LHCb Drell-Yan measurements

HANG YIN

CENTRAL CHINA NORMAL UNIVERSITY

ON BEHALF OF LHCb COLLABORATION

LHC EW PRECISION SUB-GROUP MEETING

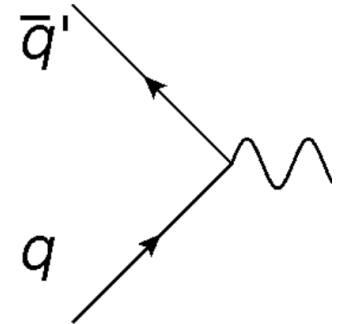


華中師範大學

# Outline

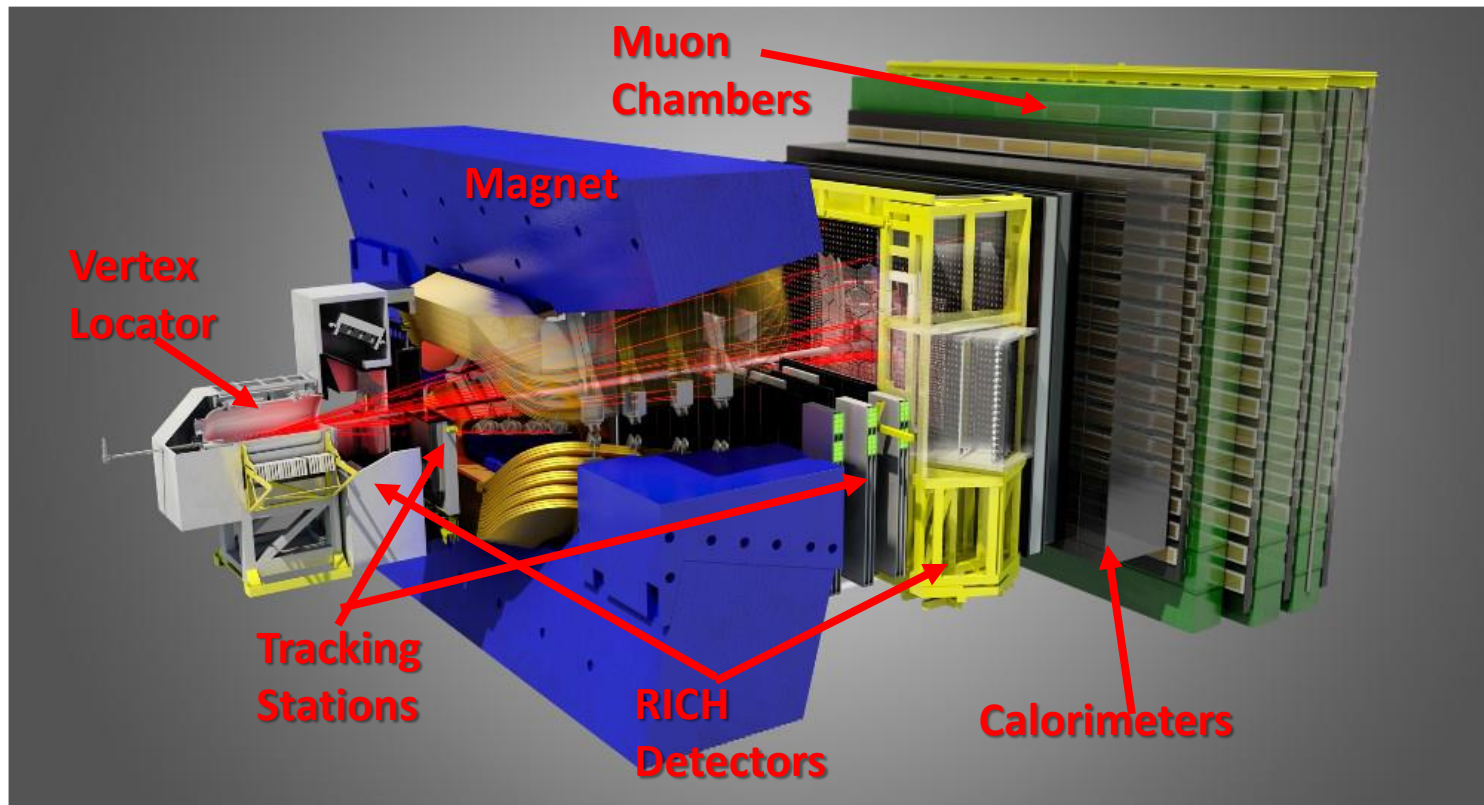
---

- LHCb detector
- Drell-Yan measurements at LHCb
  - $W/Z$  boson cross-section at 8 TeV
  - $Z$  boson cross section at 13 TeV
- Impact from the LHCb data
- Summary and outlook



JHEP 01 (2016) 155  
JHEP 10 (2016) 030  
JHEP 09 (2016) 136

# LHCb detector



LHCb is a forward spectrometer initially designed for  $b$  physics

Unique acceptance:  $2 < \eta < 5$

Momentum resolution:

- 0.4% at 5 GeV, 0.6% at 100 GeV

Excellent track and vertex reconstruction

Good PID separation

Flexible trigger

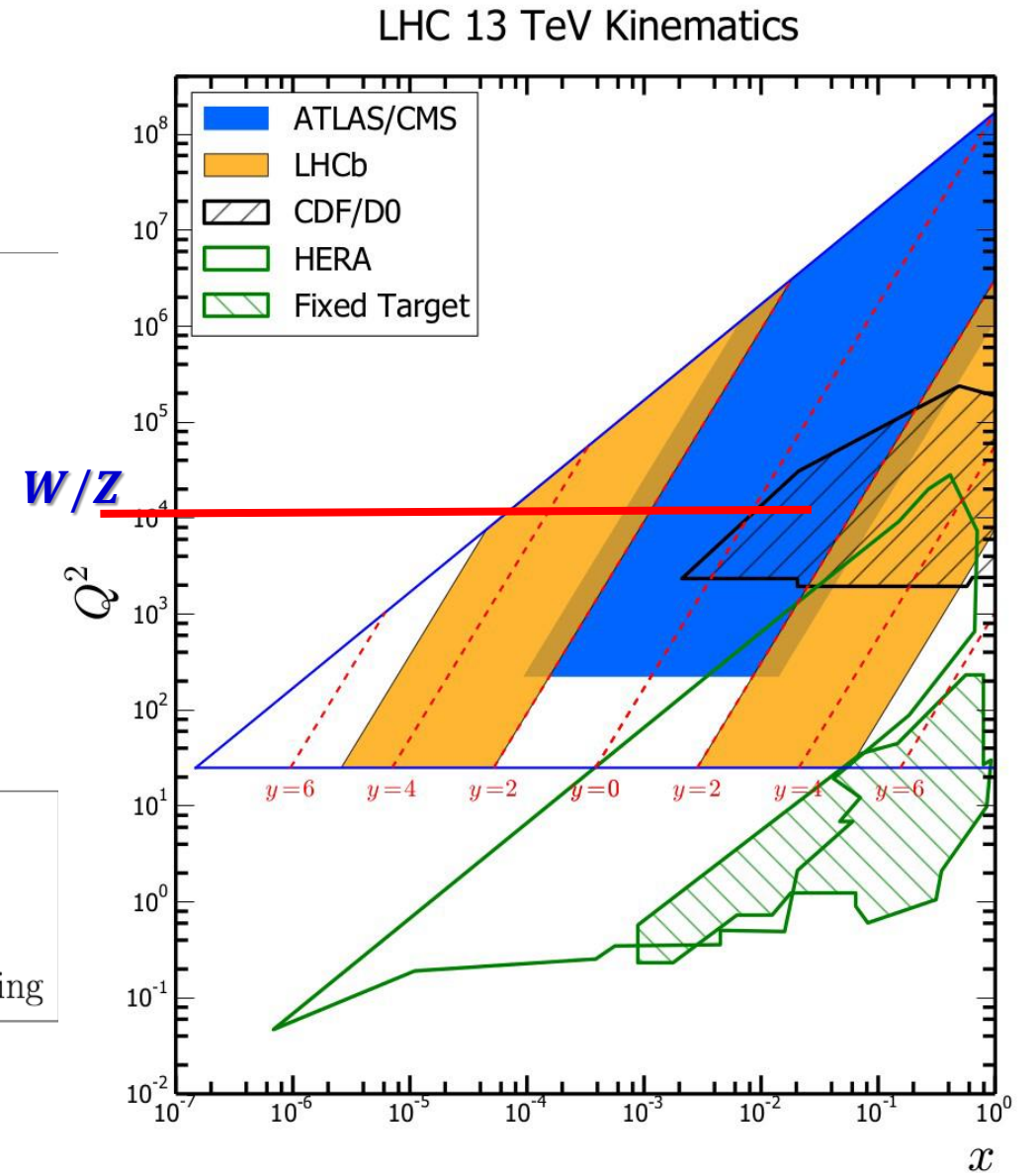
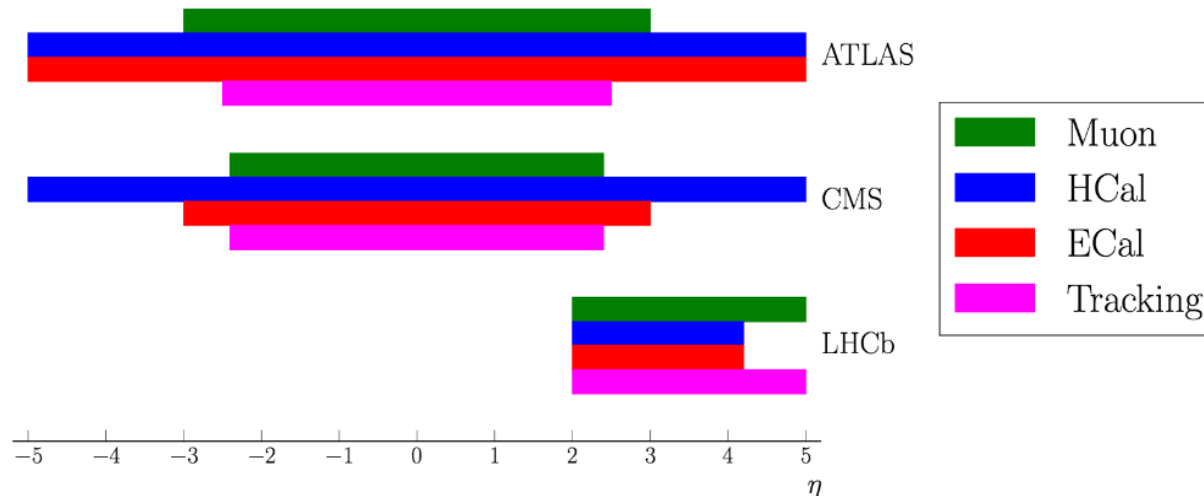
- trigger low momentum objects

JINST 3 (2008) S08005

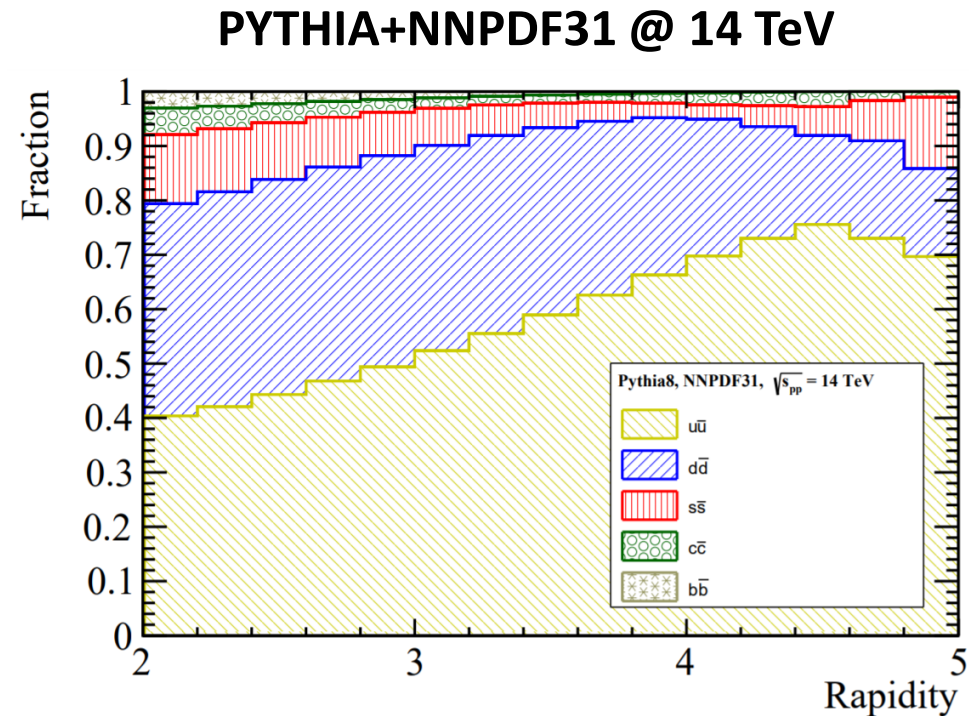
# Probe PDFs

LHCb detector provides access to Parton distribution functions (PDFs)

- High Bjorken- $x$  region
- Low Bjorken- $x$  region: unexplored by other experiments



# Z production in LHCb acceptance



In the LO, the valence u/d quark contributions become larger in the higher rapidity region

A plot get from Will Barter.

# $W \rightarrow \mu\nu$ at 8 TeV

$W \rightarrow \mu\nu$  channel:

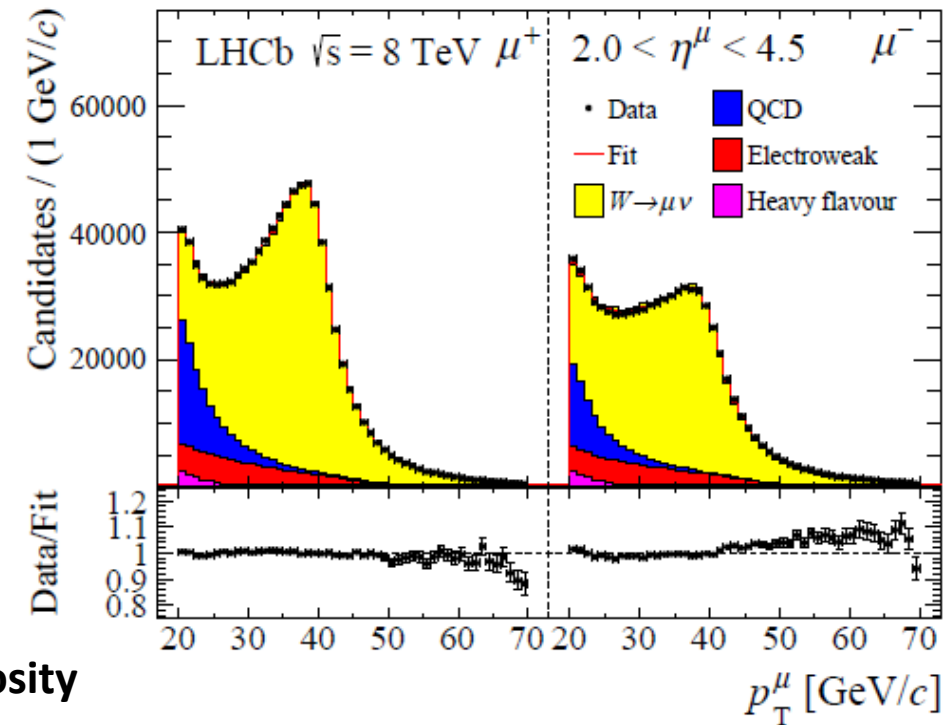
- $2.0 < \eta < 4.5$
- $p_T > 20\text{GeV}$
- Isolated muon

$$\sigma_{W^+ \rightarrow \mu^+ \nu} = 1093.6 \pm 2.1 \pm 7.2 \pm 10.9 \pm 12.7 \text{ pb},$$

$$\sigma_{W^- \rightarrow \mu^- \bar{\nu}} = 818.4 \pm 1.9 \pm 5.0 \pm 7.0 \pm 9.5 \text{ pb},$$

Stat. Syst. Beam energy luminosity

**Fiducial region:  $(2.0 < \eta < 4.5, p_T > 20 \text{ GeV})$**

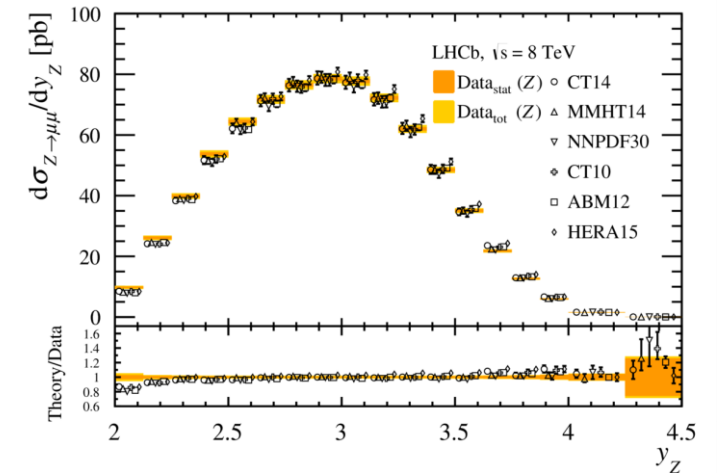
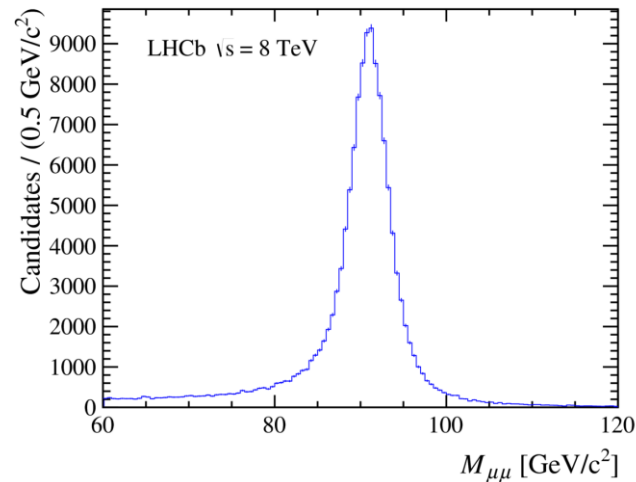


# Z production at 8 TeV

Using  $Z \rightarrow \mu\mu$  channel

## Event Selections:

- $p_T > 20$  GeV
- $2.0 < \eta < 4.5$
- $60 < M_{\mu\mu} < 120$  GeV
- High purity:
  - 99.3% for muon channel



$$\sigma_Z = 95.0 \pm 0.3 \text{ (stat.)} \pm 0.7 \text{ (syst.)} \pm 1.1 \text{ (beam)} \pm 1.1 \text{ (lumi.) pb}$$

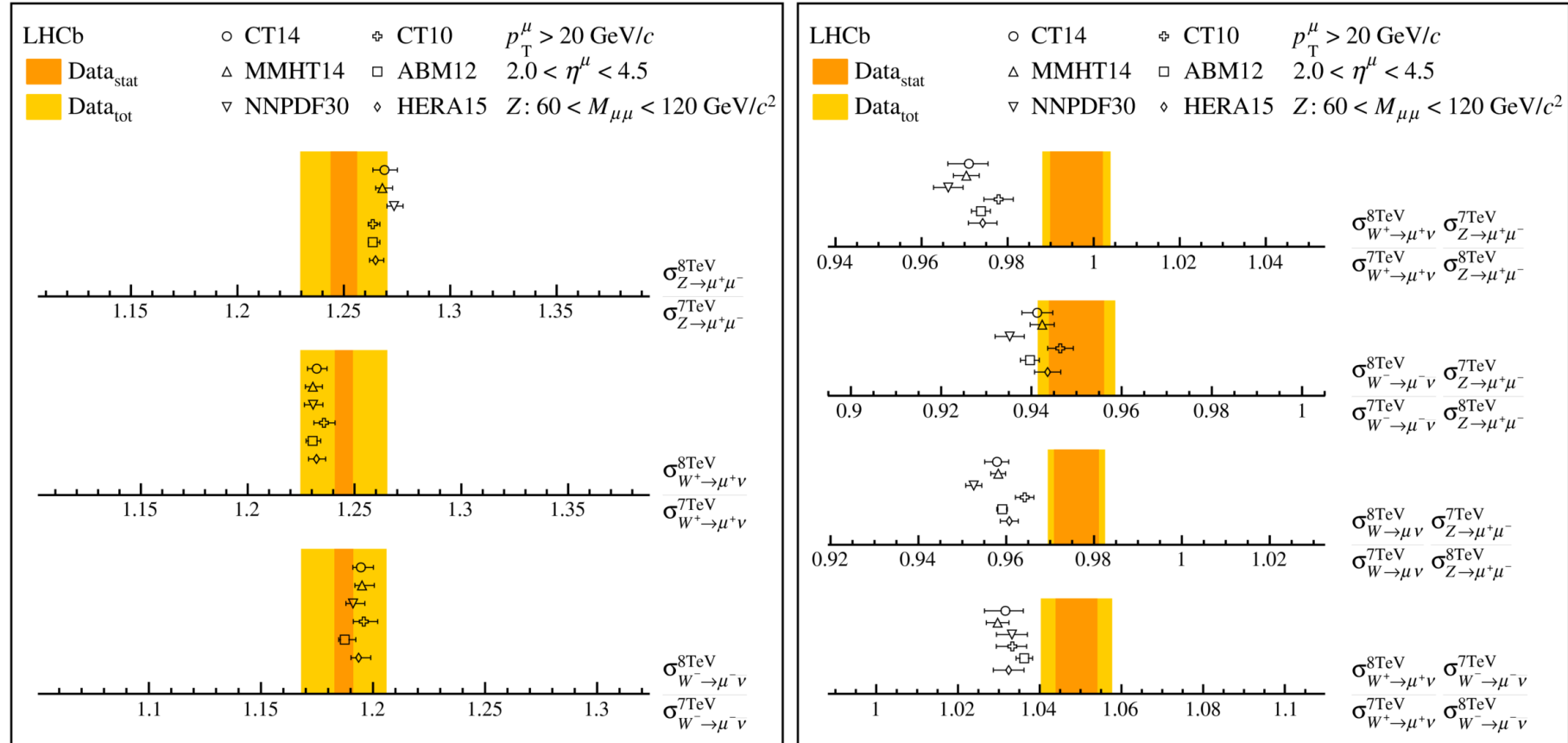
$(2.0 < \eta < 4.5, p_T > 20 \text{ GeV}, 60 < M_Z < 120 \text{ GeV})$

JHEP 01 (2016) 155



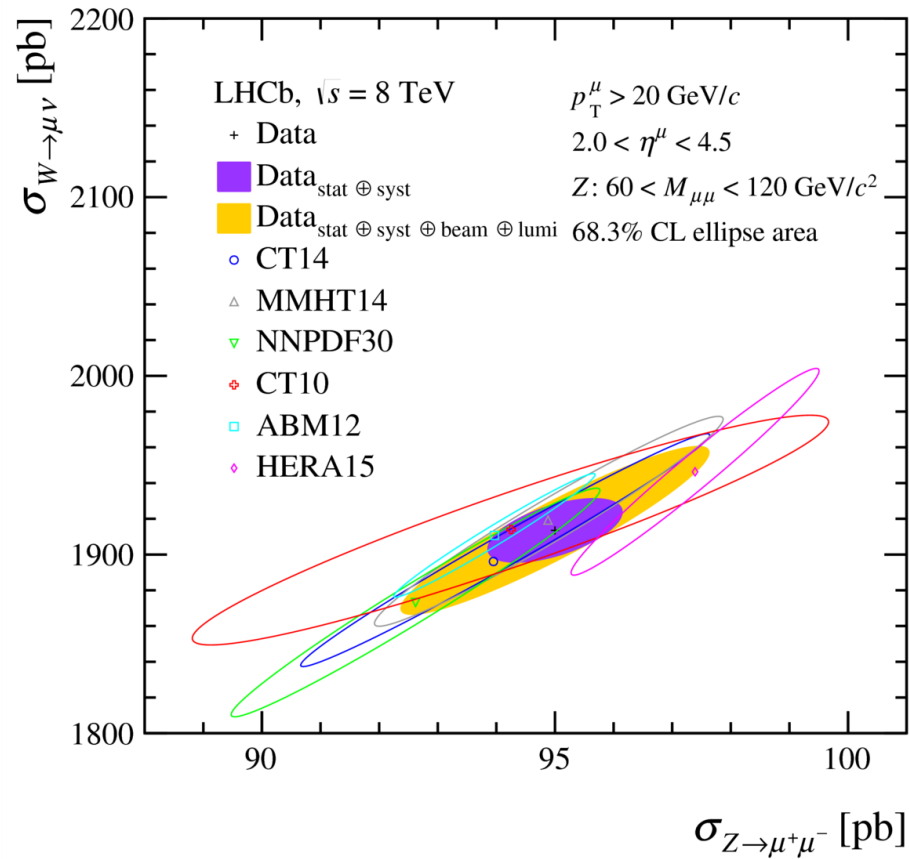
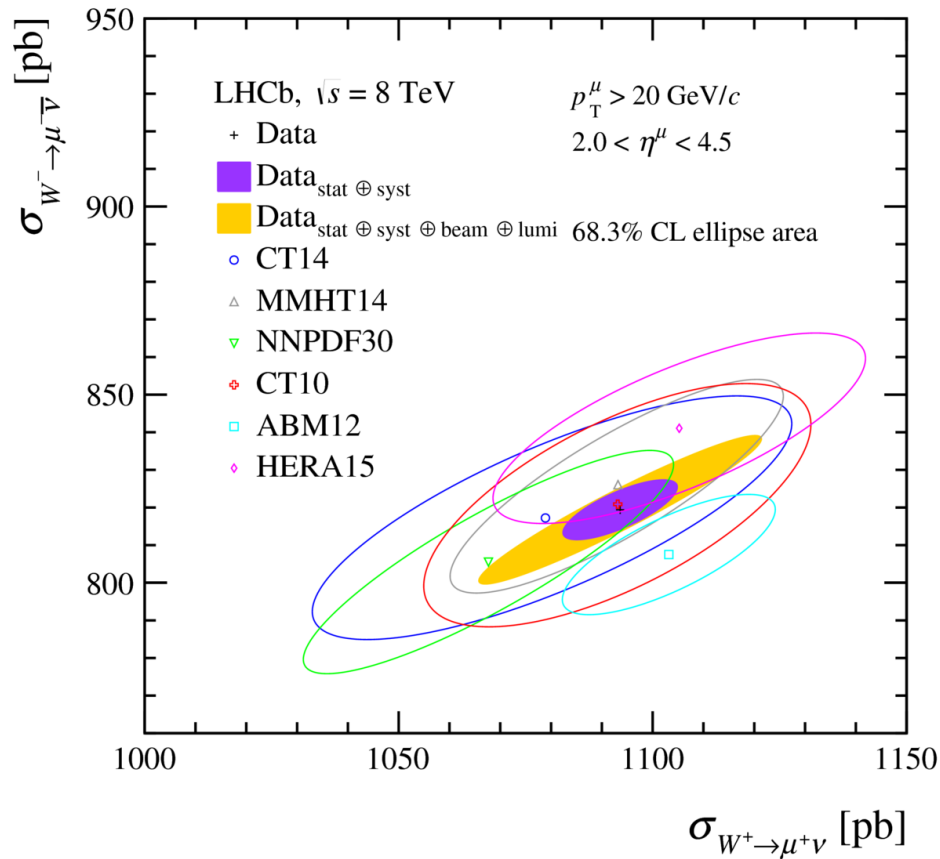
# W/Z cross section ratios

Ratios ( $W^+ / W^-$ ,  $W/Z$ , 8/7 TeV) provides even more stringent tests on SM predictions



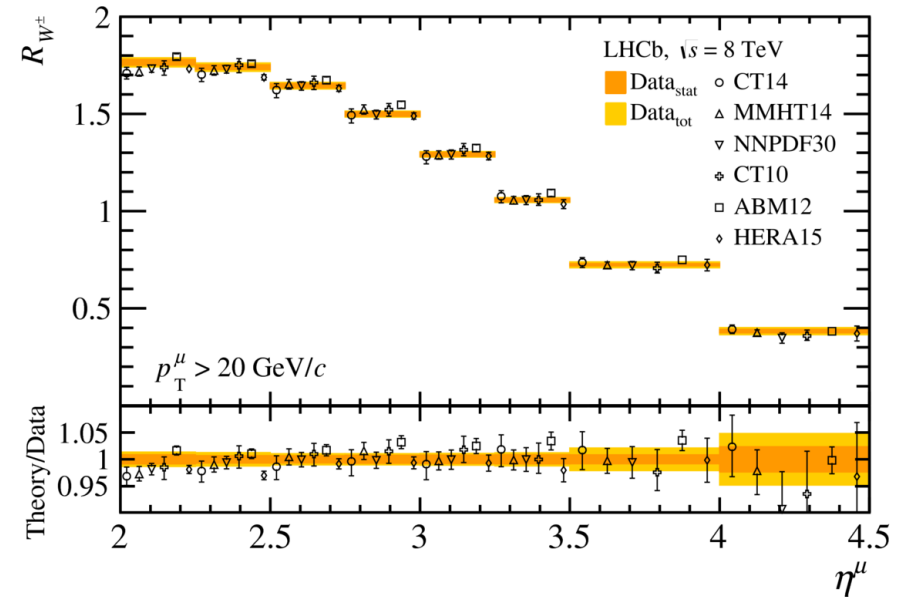
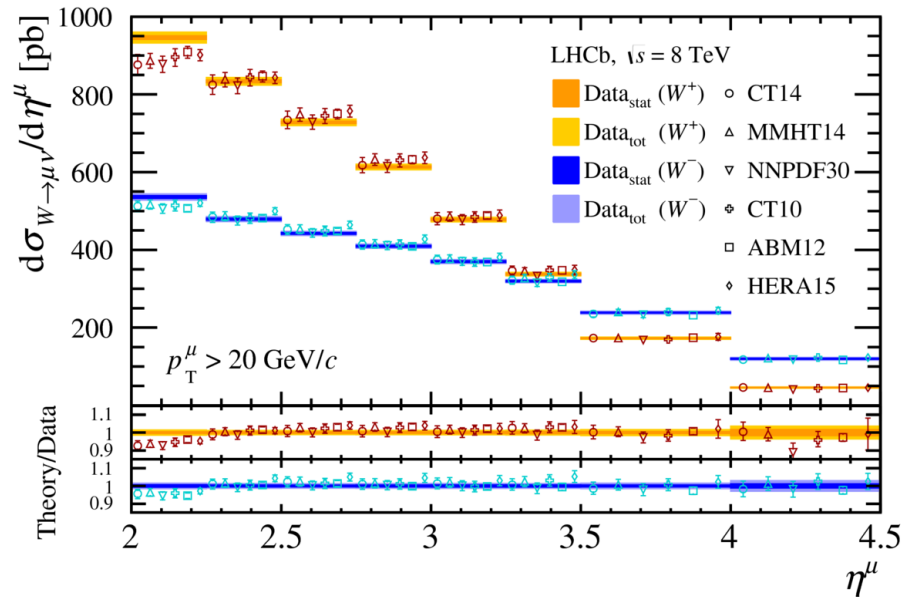


# W/Z total cross section comparison



JHEP 01 (2016) 155

# W differential cross section and ratio

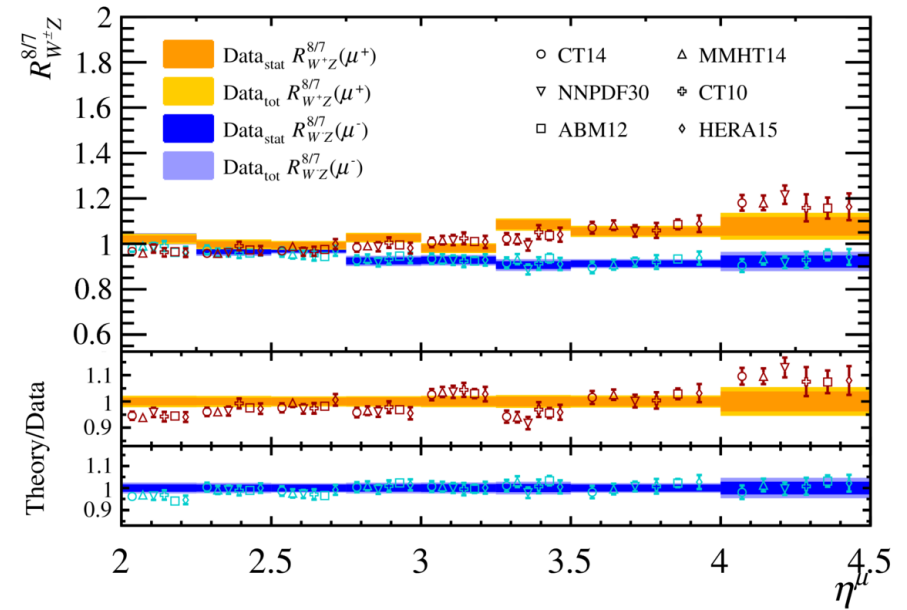
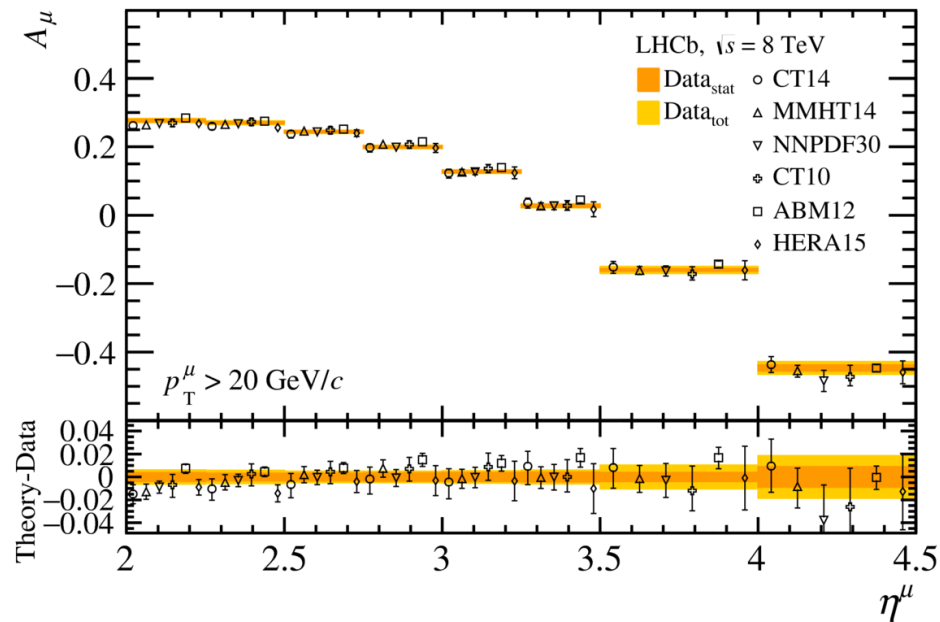


Agreement between measured results and NNLO calculations with different PDF sets

Uncertainties: dominated by luminosity and beam energy uncertainty

JHEP 01 (2016) 155

# W charge asymmetry and W/Z ratio



Agreement between measured results and NNLO calculations with different PDF sets

Uncertainties: dominated by luminosity and beam energy uncertainty

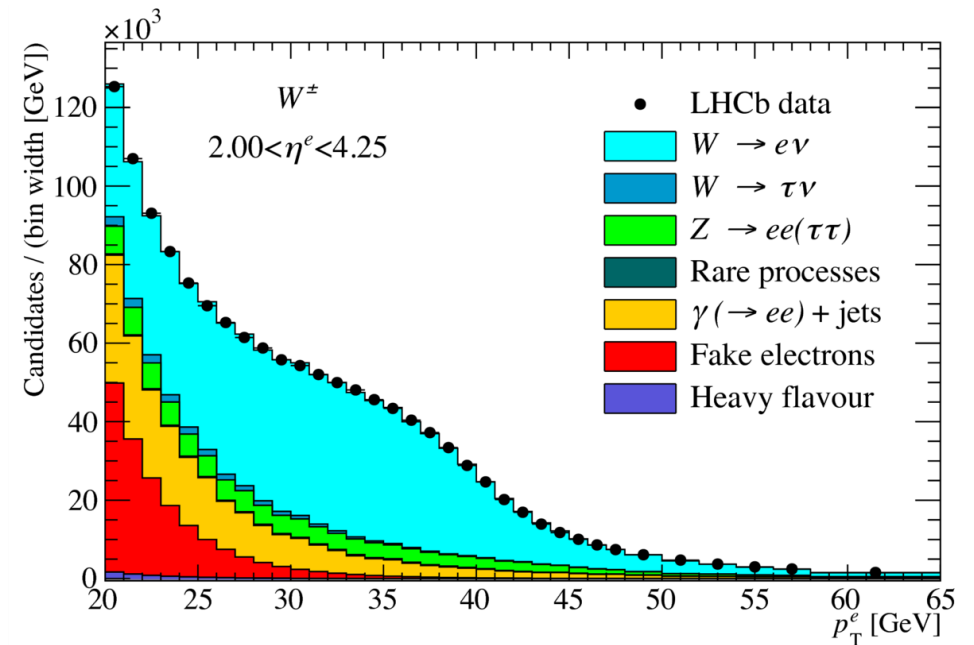
JHEP 01 (2016) 155

# $W \rightarrow e\nu$ at 8 TeV

First measurement of  $W$  with **electron** final state at LHCb

$W \rightarrow e\nu$  channel:

- $2.0 < \eta < 4.5$
- $p_T > 20$  GeV
- Electron quality cuts
- Purity: ~60%

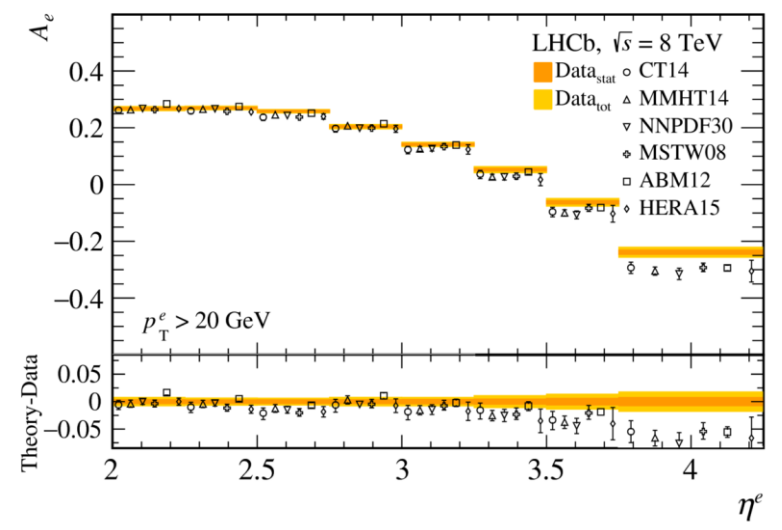
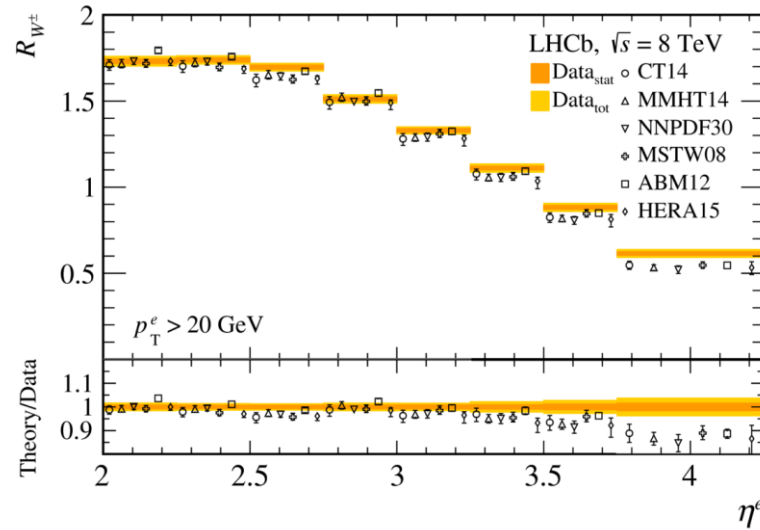
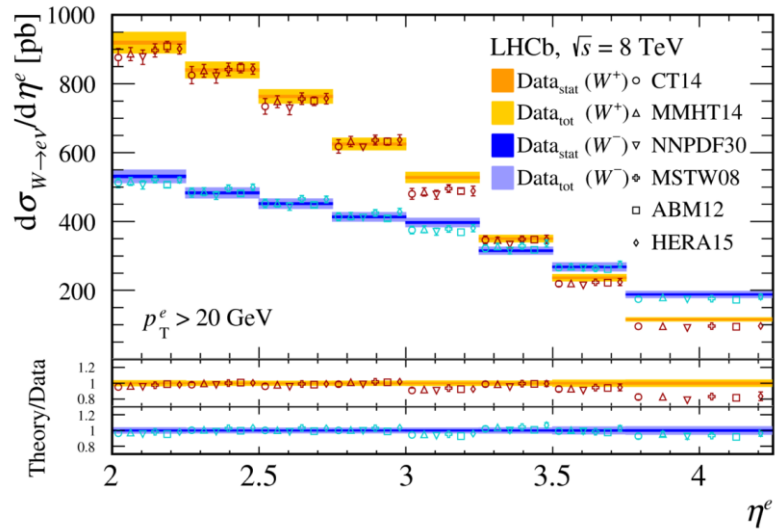


$$\sigma(W^\pm \rightarrow e^\pm\nu) = 1933.3 \pm 2.9(\text{stat.}) \pm 38.2(\text{syst.}) \pm 22.4(\text{lumi.}) \text{ pb}$$

$(2.0 < \eta < 4.5, p_T > 20 \text{ GeV})$

JHEP 10 (2016) 030

# $W \rightarrow e\nu$ at 8 TeV



Agreement between measured results and NNLO calculations with different PDF sets

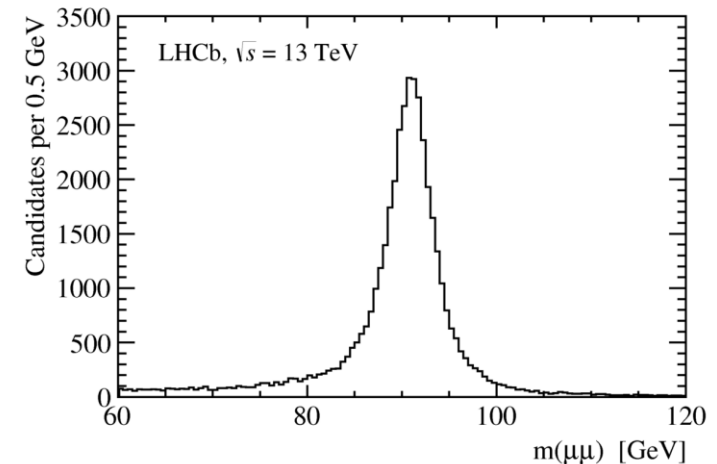
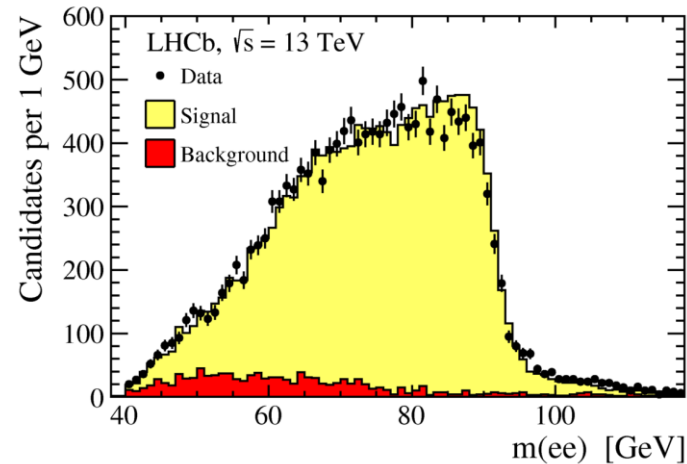
Precision test of lepton universality:  $\frac{B(W \rightarrow e\nu)}{B(W \rightarrow \mu\nu)} = 1.020 \pm 0.002 \pm 0.019$

# Z production at 13 TeV

Lepton final states  $Z \rightarrow \mu\mu$  and  $Z \rightarrow ee$

## Event Selections:

- $p_T > 20$  GeV
- $2.0 < \eta < 4.5$
- $60 < M_{\mu\mu} < 120$  GeV,  $M_{ee} > 40$  GeV
- High purity:
  - 99.2% for muon channel
  - 92.2% for electron channel



$$\sigma_Z = 194.3 \pm 0.9 \text{ (stat.)} \pm 3.3 \text{ (syst.)} \pm 7.6 \text{ (lumi.) pb}$$
$$(2.0 < \eta < 4.5, p_T > 20 \text{ GeV}, 60 < M_Z < 120 \text{ GeV})$$

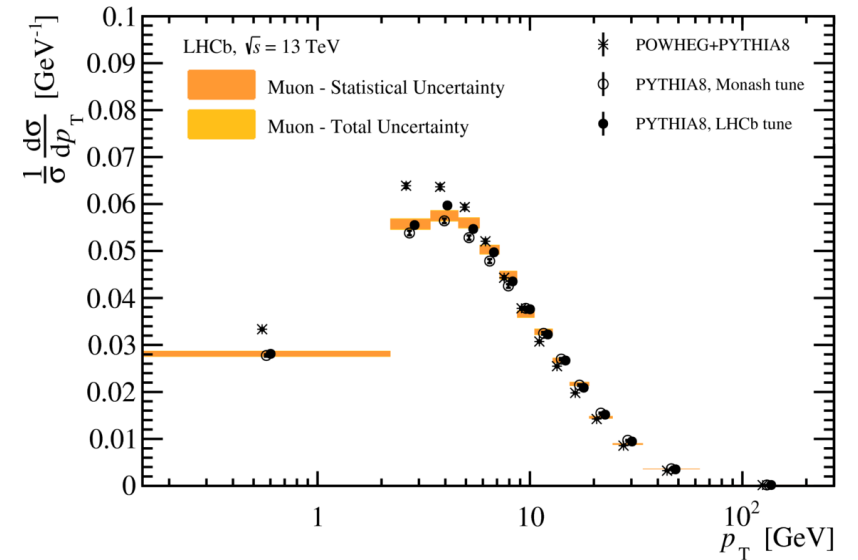
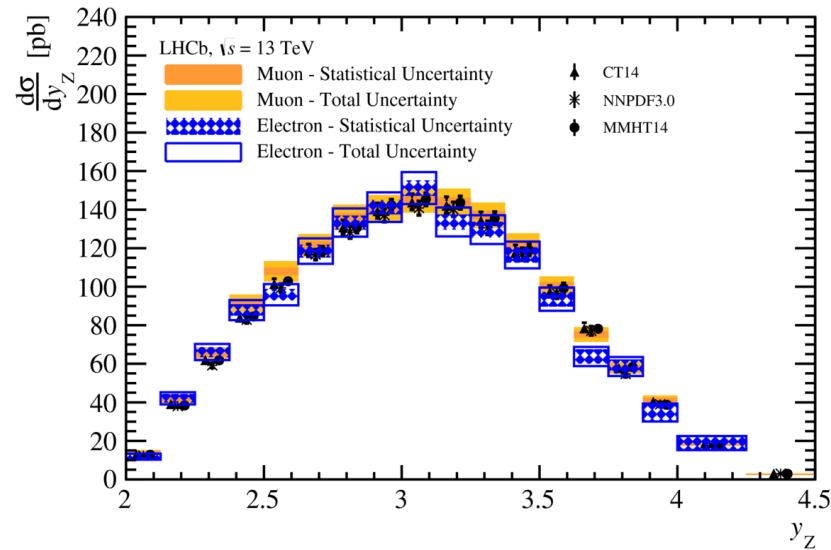
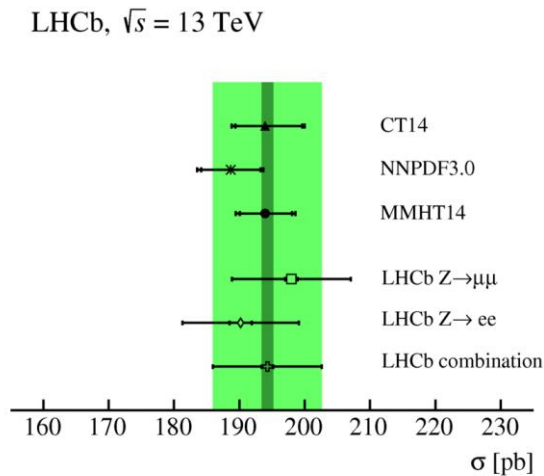
# Z production at 13 TeV

Good agreement between electron and muon channel

Differential cross-section agree with predictions

- Rapidity distribution agrees well with NNLO QCD calculation
- $p_T, \phi^*$  distributions agree better with PYTHIA8 than POWHEG predictions at low  $p_T$

Largest systematic uncertainty from the luminosity measurement (3.9%)

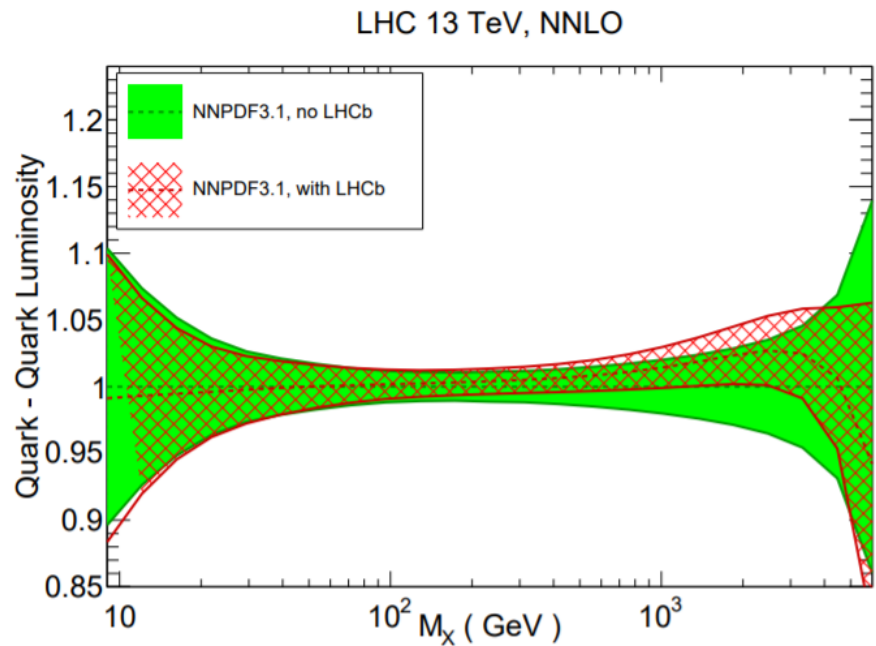


JHEP 09 (2016) 136

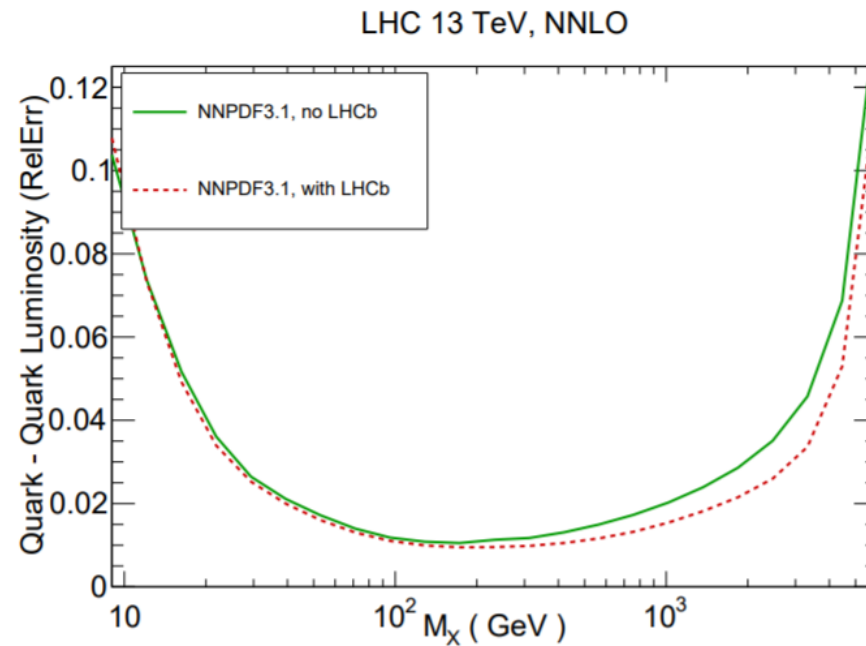


# Impact of LHCb results on NNPDF3.1

LHCb W/Z production measurements has been used in NNPDF3.1



d-quark



arXiv:1705.04468

# Conclusions

---

- **LHCb detector has unique acceptance, EW production results are complementary to that of ATLAS and CMS**
  - Sensitive to high and low Bjorken-x (down to  $10^{-5}$ ) region
  
- **Production Drell-Yan cross section measurements in the forward region**
  - Precision tests on the SM predictions
  - Provide information for future PDF constraint
  
- **Many works are in progress for new exciting measurements**

# Backup

---