Physics with Electroweak Gauge Bosons at LHCb

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1 Introduction

The LHCb detector is a single arm spectrometer fully instrumented in the forward pseudorapidity (η) region $2.0 < \eta < 5.0$. It has been designed to search for new physics in the decays of B and D mesons in proton-proton collisions, but it is also well suited for studies of QCD and Electroweak physics. The pseudorapidity coverage of LHCb overlaps with the general purpose detectors (GPDs), ATLAS and CMS, in the region $2.0 < \eta < 2.5$, but uniquely covers the region $2.5 < \eta < 5.0$, allowing complementary studies to the GPDs. More information about the LHCb detector can be found in [1]. This contribution presents an overview of the LHCb results on electroweak boson production at $\sqrt{s} = 7$ TeV.

Measurements of electroweak boson production are an important benchmark of Standard Model processes at the LHC, and allow constraints to be placed on PDFs [2]. In these measurements, LHCb provides unique information [3]. As LHCb occupies the forward region, collisions require one parton from high Bjorken-x and one from low x. PDFs at high x are already well constrained by existing measurements. However, LHCb probes previously unexplored regions of phase space at low x and a range of Q^2, from measurements of W, Z and lower mass Drell Yan production. In this region, the PDF uncertainties on cross-sections are large, and LHCb plays an important role in providing new constraints. This and the kinematic region probed by LHCb are shown in Fig. 1.

2 Electroweak Boson Production at LHCb

LHCb has measured inclusive Z production in the dimuon [4], dielectron [5] and ditau [6] channels. These measurements are performed in the fiducial acceptance

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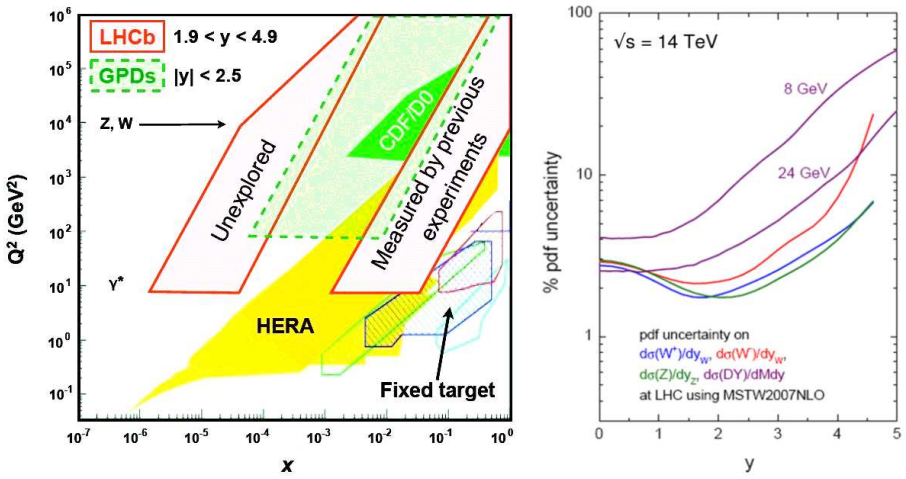

Figure 1: *Left:* The regions of x and Q^2 probed by the different LHC experiments (with $\sqrt{s} = 14$ TeV) in relation to previous measurements.
Right: The PDF uncertainty associated with the cross-section of various benchmark processes increases in the forward region ($\sqrt{s} = 14$ TeV is shown here). From [3].

$60 < M(\ell\ell) < 120$ GeV, $2.0 < \eta(\ell) < 4.5$, $p_{\rm T}(\ell) > 20$ GeV. In addition, inclusive $\mathrm{W} \to \mu\nu$ production has been measured [4], in the fiducial acceptance $2.0 < \eta(\mu) < 4.5$, $p_{\rm T}(\mu) > 20$ GeV. The results in the muon channels are summarised in Fig. 2. The LHCb results are consistent with each other and with next-to-next-to-leading order (NNLO) predictions, and test the Standard Model up to an accuracy of 1.7% (in the ratio of the W^+ to W^- production cross-sections). The LHCb measurement of the W lepton charge asymmetry, shown in Fig. 3, also probes PDF predictions as this distribution is particularly sensitive to the ratio of the up quark PDF to the down quark PDF [3]. The LHCb acceptance covers an interesting region where this distribution changes sign (W^- production becomes favoured over W^+ production). This feature is due to the $V - A$ structure of the weak interaction.

Jet production in $\mathrm{Z} \to \mu\mu$ events has also been measured [7]. Jets are reconstructed using a particle flow approach, and clustered using the anti-$k_{\rm T}$ algorithm [8] with radius parameter $R = 0.5$. The jet energies are corrected back to the hadron level. Jets are required to have $2.0 < \eta < 4.5$, $p_{\rm T} > 10$ GeV and to be separated from both the decay muons of the Z in $\eta - \phi$ space by a distance $\Delta R > 0.4$. The fraction of jet events is found to be $0.229 \pm 0.006 \pm 0.009$, where the first uncertainty is statistical, and the second is systematic. The results are compared against a NLO prediction from FEWZ [9] using MSTW08 PDFs [2], and found to be consistent.

LHCb has also measured low mass Drell-Yan production in the $\mu\mu$ channel [10] in the fiducial acceptance $2.0 < \eta(\mu) < 4.5$, $5 < M(\mu\mu) < 120$ GeV, $p(\mu) > 10$ GeV,

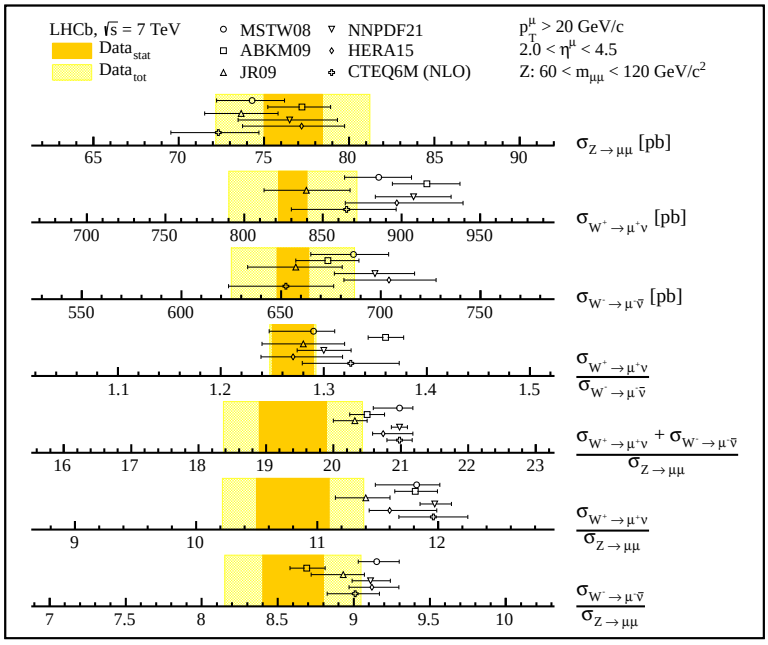

Figure 2: LHCb measurements (bands) for the W $\to \mu\nu$ and the Z $\to \mu\mu$ cross-sections, and their ratios, are consistent with NNLO predictions (points). From [4].

and $p_{\rm T}(\mu) > 3(15)$ GeV for $M(\mu\mu) > 5(40)$ GeV. NLO predictions agree reasonably well with the LHCb measurement.

3 Conclusions

Electroweak boson production has been studied extensively at LHCb. Measurements at LHCb are complementary to those from the GPDs. The results presented are consistent with Standard Model theory predictions, and can be used to provide new constraints on PDFs in a previously unexplored region of phase space.

References

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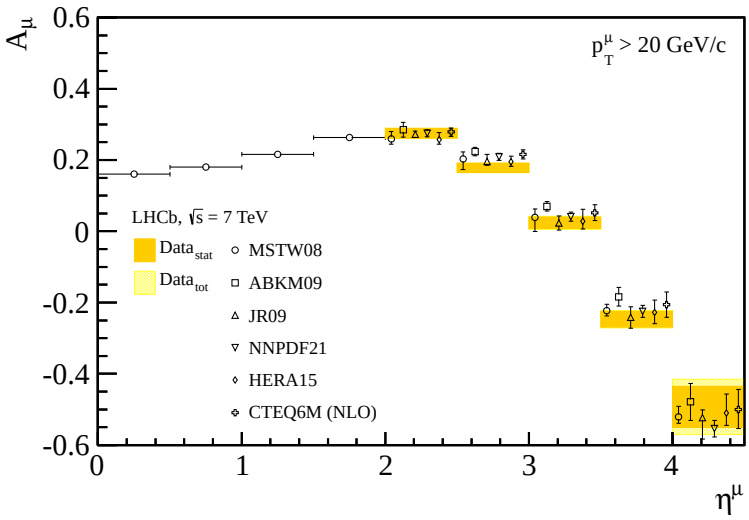

Figure 3: The lepton charge asymmetry, $\frac{\sigma(W^+)-\sigma(W^-)}{\sigma(W^+)+\sigma(W^-)}$ as a function of $\eta(\mu)$ measured at LHCb (shown as bands) is consistent with NNLO predictions (points). From [4].

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