1 Introduction

Measurements of the inclusive production cross sections of the W and Z bosons at hadron colliders constitute an important test of the Standard Model. The theoretical calculations involve parton distribution functions (PDF) and different couplings of the partons to the weak bosons. They are affected by significant higher-order QCD corrections. Calculations of the inclusive W and Z production cross sections have been carried out at next-to-leading order (NLO) [1–3] and next-to-next-to leading order (NNLO) in perturbation theory [4–8].

The production of W and Z bosons at hadron colliders was measured previously by the UA1 [9] and UA2 [10] experiments at $\sqrt{s}$ = 0.63 TeV at the CERN Sp$\bar{\text{p}}$S and by the CDF [11–13] and D0 [14, 15] experiments at $\sqrt{s}$ = 1.8 TeV and $\sqrt{s}$ = 1.96 TeV at the Fermilab Tevatron proton-antiproton colliders. In contrast to proton-antiproton collisions, the cross sections for W^+ and W^- production are expected to be different in proton-proton collisions due to different valence quark distributions of the u and d quarks. Most recently, the RHIC collider experiments [16,17] have reported the first observation of W production in proton-proton collisions at $\sqrt{s} = 0.5$ TeV.

W and Z bosons are expected to be produced abundantly at the Large Hadron Collider (LHC) [18]. The projected large dataset and the high LHC energy will allow for detailed measurements of their production properties in a previously unexplored kinematic domain. These conditions, together with the proton-proton nature of the collisions, will provide new constraints on the parton distribution functions and will allow for precise tests of perturbative QCD. Besides the measurements of the W and Z boson production cross sections, the measurement of their ratio R and of the asymmetry between the W^+ and W^- cross sections constitute important tests of the Standard Model. The ratio R can be measured with a higher relative precision because both experimental and theoretical uncertainties partially cancel. With larger data sets this ratio can be used to provide constraints on the W-boson width Γ_W [13].

This paper describes the first measurement of the W^+, W^- and Z/γ^* boson production cross sections in proton-proton collisions at $\sqrt{s}$ = 7 TeV by the ATLAS [19] experiment at the LHC. The measurements are based on data corresponding to an integrated luminosity of approximately 320 nb^{-1}. The inclusive Z/γ^*-production-cross section is measured within the mass range $66 < m_{\ell\ell} < 116$ GeV. In addition to the individual cross-section measurements, first measurements of the ratio R of the W to Z cross sections and of the $W \to \ell\nu$ charge asymmetry are presented. Throughout this paper the label “Z” refers to Z/γ^*.

The paper is organized as follows: after a short description of the ATLAS detector, the data set and the Monte-Carlo samples in Sections 2 and 3, the identification of electrons, muons and the measurement of the transverse missing energy are discussed in Section 4. In Section 5, the selection of $W \to \ell\nu$ and $Z \to \ell\ell$ candidates is presented. Section 6 is devoted to a detailed discussion of backgrounds in these samples. The measurement of the $W \to \ell\nu$ and $Z \to \ell\ell$ cross sections and of their ratio is presented in Section 7 together with a comparison to theoretical predictions. The measurement of the $W \to \ell\nu$ charge asymmetry is discussed in Section 8.

2 The ATLAS detector

The ATLAS detector [19] at the LHC comprises a thin superconducting solenoid surrounding the inner-detector and three large superconducting toroids arranged with an eight-fold azimuthal coil symmetry placed around the calorimeters, forming the basis of the muon spectrometer.

The Inner-Detector (ID) system is immersed in a 2 T axial magnetic field and provides tracking information for charged particles in a pseudorapidity range matched by the precision measurements of the electromagnetic calorimeter; the silicon tracking detectors, pixel and silicon microstrip (SCT), cover the