Measurement of W and Z boson production in pp at sqrt(s) = 7 TeV with the ATLAS detector

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PROCEEDINGS OF SCIENCE

Measurement of W and Z production at √s= 7 TeV with the ATLAS detector

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In spring 2010, the LHC has delivered its first proton-proton collisions at a centre of mass of 7 TeV. The validation of the detector performance started with the measurement of some Standard Model well known processes. This paper presents the measurement of the W and Z cross section in electron and muon final states, which constitute the first sample of isolated high transverse momentum leptons. Clean signals have been extracted and the cross sections have been measured with 17 nb^{-1} for the W channel and about 220 nb^{-1} for the Z channel. All results agree with the theoretical predictions (computed at the Next to Next Leading Order) within the uncertainties equally shared between statistic, systematic and luminosity errors at the level of 10-15%.

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[1] Speaker

1. Introduction

In April 2010, the LHC has delivered its first proton-proton collisions at a center of mass of 7 TeV. The decays of W and Z into leptons (electrons and muons) offer a good opportunity to study high p_T isolated leptons. Such a sample can be used to validate performance (lepton identification and efficiency measurement with Tag and Probes technique, calibration and energy scale, study of missing transverse energy for the W….), and on longer term a precise measurement of the production cross section is a stringent test of higher order of QCD and parton density function of the proton in a new energy regime. Moreover these final states reveal to be also potential background for new search physics and need to be measured. At the NNLO, the predicted cross section is respectively 10.46 nb (0.96 nb in a mass window 66-116 GeV) for the $W \rightarrow l\nu$ ($Z \rightarrow ll$) with a 4% theoretical uncertainty. This paper presents the first measurement obtained with the ATLAS detector using an integrated luminosity of 17 nb^{-1} (~220 nb^{-1}) for the W (Z) [1][2].

2.Data sample and object reconstruction and identification

The data sample consists of about 17 nb^{-1} (220 nb^{-1}) collected up to end of June for the W (Z) analysis. The luminosity is known with a 11% uncertainty extracted from van der Meer scan. The detectors are required to operate in nominal conditions. The events are selected using a L1 trigger based on calorimeter for the electrons with a 5 GeV transverse energy threshold and on coincidences in the trigger stations located in the toroid system for the muons. Collision candidates are selected by requiring a primary vertex with at least three tracks, consistent with the beam spot position.
The electrons are reconstructed from a calorimeter cluster found with a sliding window algorithm with a 2.5 GeV E_T threshold, matched to an inner detector track. The identification relies mostly on track quality, shower leakage, lateral profile in electromagnetic calorimeter and finally using the transition radiation signal. A 72 % (90 %) efficiency is expected for the tight (resp medium) electron definition for p_T >20 GeV while a 10^5 (7.10^3) rejection against jet is reached [3].
The muons are reconstructed in two different ways: in a stand-alone mode using only the muon spectrometer chambers and trigger chambers extrapolated to the interaction point, or in a combined way by associating the inner detector track with the muon spectrometer track. The reconstruction and identification is larger than 94 % for a p_T>10 GeV[4].
The transverse missing energy is based on calorimeter information for the electron final state. The x and y components are computed from the calorimeter cell energies belonging to calibrated three-dimensional topological clusters. For the muon final state, the reconstructed muon momenta are taken into account in addition to the calorimeter information used for the electrons [5].

3.W cross section measurement

Both QCD background with fake lepton and electroweak background ($W \rightarrow \tau\nu$ or $Z \rightarrow ll$ with fake missing transverse energy) have been considered to define the analysis selection:

- **Electron channel**: the distribution of the missing transverse energy is displayed in Fig 1 after requiring an electron with tight identification and p_T > 20 GeV. At this stage of the selection, the QCD background is still dominant and a missing E_T cut at 25 GeV is applied, but the W signal is already well established. An additional cut on the transverse mass at 40 GeV is used to further reduce the QCD background. After these cuts 46 candidates are selected. The remaining QCD background is measured with a data driven method based on the electron calorimeter isolation and found to be 1.1±0.2(stat)±0.4(syst), while the electroweak background (mainly $W \rightarrow \tau\nu$) has been estimated from Monte Carlo to 1.5±0.1(syst)±0.1(lumi).

- **Muon channel:** The distribution of the missing transverse energy is displayed in Fig 2 after requiring a muon with $p_T > 20$ GeV and applying track isolation around the muon. A cut on the missing transverse energy and the transverse mass is also applied. After all selection, 72 events are selected. On contrary to the electron channel, the electroweak background is the dominant one with a large contribution from $Z \rightarrow \mu\mu$, 4.4±0.2(syst)±0.5(lumi), while the QCD using data driven approach is 0.9±0.3(stat)±0.6(syst).

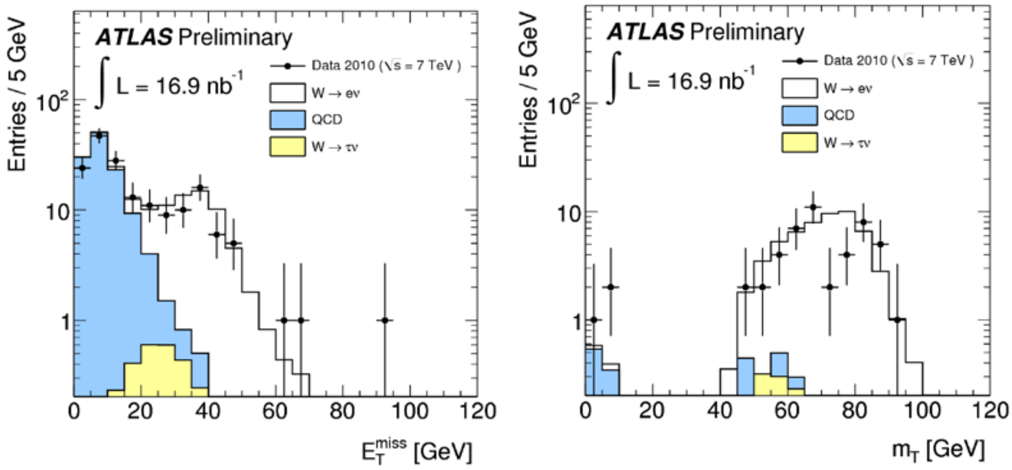

Figure 1 : Missing transverse energy (left) and transverse mass after missing transverse energy cut at 25 GeV (right) for candidates and Monte Carlo in electron channel

The cross section is extracted through the following formula:

$$\sigma_W \times Br(W \rightarrow l\nu) = N^{sig}/(A_W\, C_W\, L_{int})$$

N^{sig} is the number of background subtracted signal events. L_{int} is the integrated luminosity. A_W is the geometrical and kinematics acceptance computed at born level : 0.463 (0.480) for electron (muon) channel . This factor is mainly limited by the knowledge of the parton density function (pdf) of the proton and the modeling of the W production at LHC; using different generators and sets of pdf, a 3 % conservative systematic error has been quoted. Finally C_W is a correction factor which includes the trigger, reconstruction, identification and selection cuts efficiencies within the acceptance. Ultimately this factor will be derived directly from the data (for instance with Tag & Probe and Z) but due to the limited statistics it is extracted from the simulation. In the electron channel C_W= (65.6±5.3)% and the main source of systematic comes from the electron identification due to some discrepancy between data and simulation for some variables or an insufficient knowledge and description of the material upstream of the calorimeter. In the muon channel, C_W= (81.4±5.6)% and the systematic are well balanced between trigger efficiency, identification efficiency and energy scale. The resulting cross sections are:

$$\sigma(W \rightarrow e^{\pm}\nu) = 8.5 \pm 1.3\ (stat) \pm 0.7\ (syst) \pm 0.9\ (lumi)\ \ nb$$

$$\sigma(W \rightarrow \mu^{\pm}\nu) = 10.3 \pm 1.3\ (stat) \pm 0.8\ (syst) \pm 1.1\ (lumi)\ \ nb$$

They agree well within the uncertainties with the prediction cross sections at NNLO.

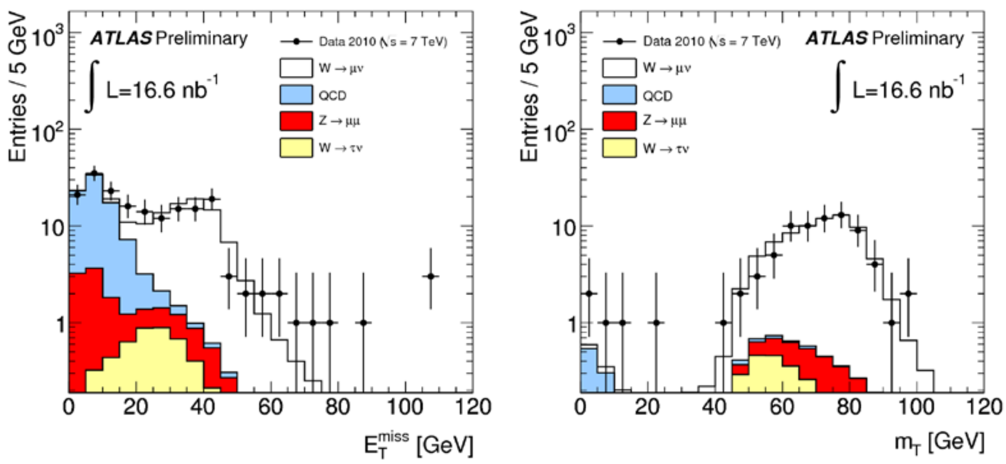

Figure 2 : Missing transverse energy (left) and transverse mass after missing transverse energy cut at 25 GeV (right) for candidates and Monte Carlo in muon channel

4. Z cross section measurement

The Z cross section is also measured using about 220 nb^{-1}. In the electron channel, two candidates of opposite charge and identified as medium are required. In the muon channel two isolated muon candidates of opposite charge are required. All leptons should have $p_T > 20$ GeV. In the mass range [66-116] GeV, 46 candidates (resp 72) are selected in the electron (resp muon) channel. The total number of expected background events in the electron (muon) channel is 0.49±0.07±0.05 (0.17±0.01±0.01). Applying a similar procedure to extract the acceptance and correction factor as in the W analysis, the following cross sections have been measured:

$$\sigma(Z\rightarrow ee) = 0.72 \pm 0.11 \text{ (stat)} \pm 0.1 \text{ (syst)} \pm 0.08 \text{ (lumi) nb}$$

$$\sigma(Z\rightarrow \mu\mu) = 0.89 \pm 0.10 \text{ (stat)} \pm 0.07 \text{ (syst)} \pm 0.10 \text{ (lumi) nb}$$

5. Conclusion

The W and Z production cross-sections in electron and muon channel have been measured with the ATLAS experiment using respectively 17 and 220 nb^{-1}. The results agree well within the uncertainty with the NNLO order cross section prediction and already demonstrate the good performance reached by the ATLAS detectors.

References

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